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ABSTRACT

These 20 papers were selected from those presented at the 10th International Conference on College Teaching and Learning. Papers have the following titles and authors: (1) "Case It! A Project to Integrate Collaborative Case-Based Learning into International Undergraduate Biology Curricula" (Bergland, Klyczek, Lundeberg, Mogen, Johnson); (2) "The Warrior Island Game: Virtual Combat in the Economics Classroom" (Bohler and McDowell); (3) "An Interactive Multimedia Intelligent Tutoring System" (Butz); (4) "Assessing Models of Information Literacy" (Catts and Appleton); (5) "Electronic Portfolios: Applications in Student Assessment" (Cole, Ryan, Mathies, Clemens); (6) "Digital Portfolios: Issues and Solutions" (Fritz); (7) "Developing a Discourse Community: Teaching Biochemistry Using the World Wide Web" (Gilmer); (8) "Computer-Mediated Critical Thinking: The Vee Heuristic" (Jamieson); (9) "Storytelling Techniques in the Teaching of Mathematics and Computer Science" (Joel); (10) "Integrating Learning Technology into the Liberal Arts Tradition" (Jones and Tarry); (11) "The Effects of Gender and Academic Program on Learning Styles and Attitudes of Undergraduate Students Using Multimedia, Web-Based Anatomy Labs" (Katz, Maitland, Hannah, Burggraff, King); (12) "Teaching Within the Dilemma Science Technology and Small College Consortia" (Lassiter); (13) "Beyond Constructivism in the Life Sciences" (Linich); (14) "Intentional and Incidental Learning" (Madden); (15) "Activity Visualization and Formative Assessment in Virtual Learning Environments" (Nulden and Hardless); (16) "Field Dependence Contextual Learning and Academic Achievement in Engineering Education" (O'Brien, Butler, Bernold); (17) "Collaborative Learning on the World Wide Web Using a Problem-Based Learning Approach" (Oliver, Omari, Stoney); (18) "Transformational Growth and Educational Change" (Phillips); (19) "Undergraduate Learning Modes and New Technologies: Lessons for the Faculty" (Pollak); and (20) "Technology in Problem-Based Learning Courses How Can It Help?" (Rau). (Individual papers contain references.) (DB)

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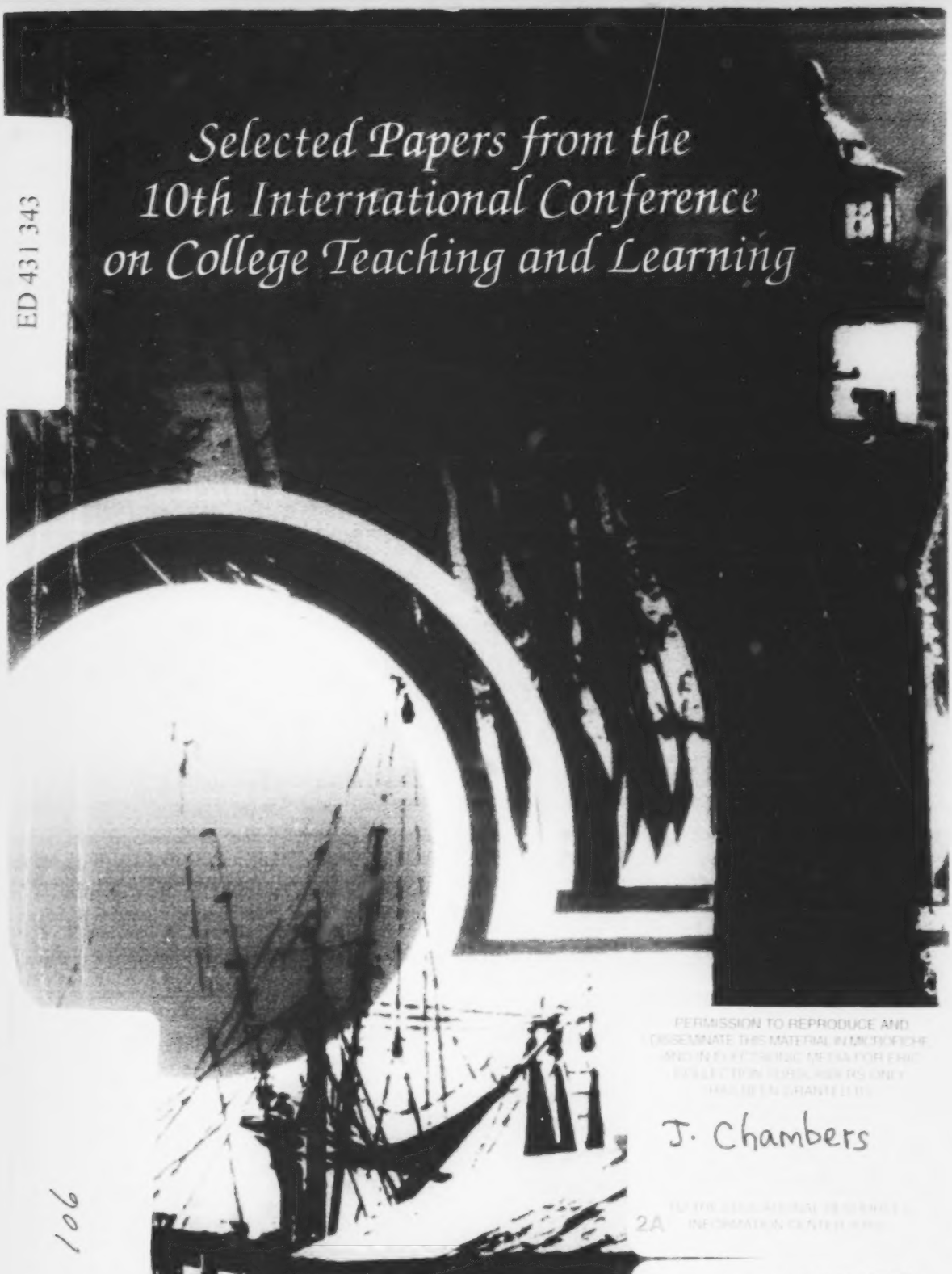
Selected Papers from the 10th International Conference on College Teaching and Learning



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The Center
for the Advancement of
Teaching and Learning

SELECTED PAPERS
from the
10th INTERNATIONAL CONFERENCE
on
COLLEGE TEACHING
AND LEARNING

Edited by
Jack A. Chambers

Florida Community College
at Jacksonville

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FOREWORD

The Center for the Advancement of Teaching and Learning was developed in 1987 when Florida Community College at Jacksonville (FCCJ) accepted K. Patricia Cross' challenge to use the classroom as a modern laboratory for conducting experiments to gauge the impact of teaching on student learning.

The Center, with the philosophy that classroom teachers are the key to improving student learning, is composed of faculty members under the guidance of a steering committee which consists of faculty from each of five campuses of Florida Community College. Part of the Center's success can be attributed to the numerous opportunities given to faculty to test their teaching ideas and to put research results into practice.

The Center sponsors programs supporting faculty research mini-grants, case studies, portfolios, classroom research, cooperative learning, faculty workshops, and adjunct faculty development. In recent years, the Center received the Theodore M. Hesburgh Certificate of Excellence for its faculty development programs.

In an effort to stimulate creative discussion and promote experimentation to improve the teaching/learning process, as well as to honor those who have already significantly improved learning in higher education, the Center annually sponsors an international conference. The conference features recognized educational leaders in diverse areas of teaching, learning and technology. Since its

inception, the conference has grown yearly and now attracts over a thousand scholars from around the world. This annual publication, *Selected Papers*, resulted from faculty interest in preserving and communicating some of the outstanding contributions to each conference.

Many people are responsible for the success of the conferences. Thanks to all participants--featured speakers and workshop leaders; presenters from universities, liberal arts and community colleges throughout the United States and abroad; and faithful attendees. A special thanks to the Steering Committee for The Center for the Advancement of Teaching and Learning and to Bill Martin, Jack Chambers, Brenda Boccard, John Mullins, Edith Cooper, Jeana Davis, B.J. Schukis, Sheila Bambacus, Edna Taylor, Ida Brown and Dennis Lewis.

Like the International Conference, this journal continues to grow and broaden its focus. This year's publication contains 20 articles from the *Tenth International Conference on College Teaching and Learning* which represent a cross-section of the nearly 300 faculty presentations. More than 60 papers were submitted for consideration in this year's journal. Those that were selected for inclusion were juried by FCCJ faculty members.

Papers were judged on the following criteria:

*Quality of content.

*Quality of writing and presentation

Selected Conference Papers

*Focus of the paper (i.e., teaching, learning, technology)

*Discipline

*Appeal to an audience of professional, post-secondary educators

*Theoretical or practical applications

We hope you will find the ideas presented herein applicable and inspirational to your own research and teaching. Please plan to join us at the *Eleventh International Conference on College Teaching and Learning*, April 12-15, 2000, in Jacksonville.

Carolyn Phanstiel
Professor of English

John Mullins
Professor of Biology

Joann Carpenter
Professor of History

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CASE IT!--A PROJECT TO INTEGRATE COLLABORATIVE CASE-BASED LEARNING INTO INTERNATIONAL UNDERGRADUATE BIOLOGY CURRICULA

Mark Bergland
Karen Klyczek
Mary Lundeberg
Kim Mogen
Douglas Johnson
University of Wisconsin – River Falls

INTRODUCTION

Case It! is a project designed to integrate molecular biology computer simulations into a framework for case-based learning by introductory biology students worldwide. Students use investigative simulation tools to study problems in human genetics, forensics, phylogeny, politics and other disciplines and then defend their results using the 3-P's approach of the BioQUEST Curriculum Consortium: Problem-posing, Problem-solving, and Peer persuasion (Peterson & Jungck, 1988).

Case-based learning can be an effective way to engage students in learning since it encourages self-directed, problem-motivated investigations (Brooks & Brooks, 1993; Stepien & Gallagher, 1993; Waterman, 1996). This paper provides an overview of the project and results of class-testing at the University of Wisconsin-River Falls and Westfield State College during the spring semester of 1998.

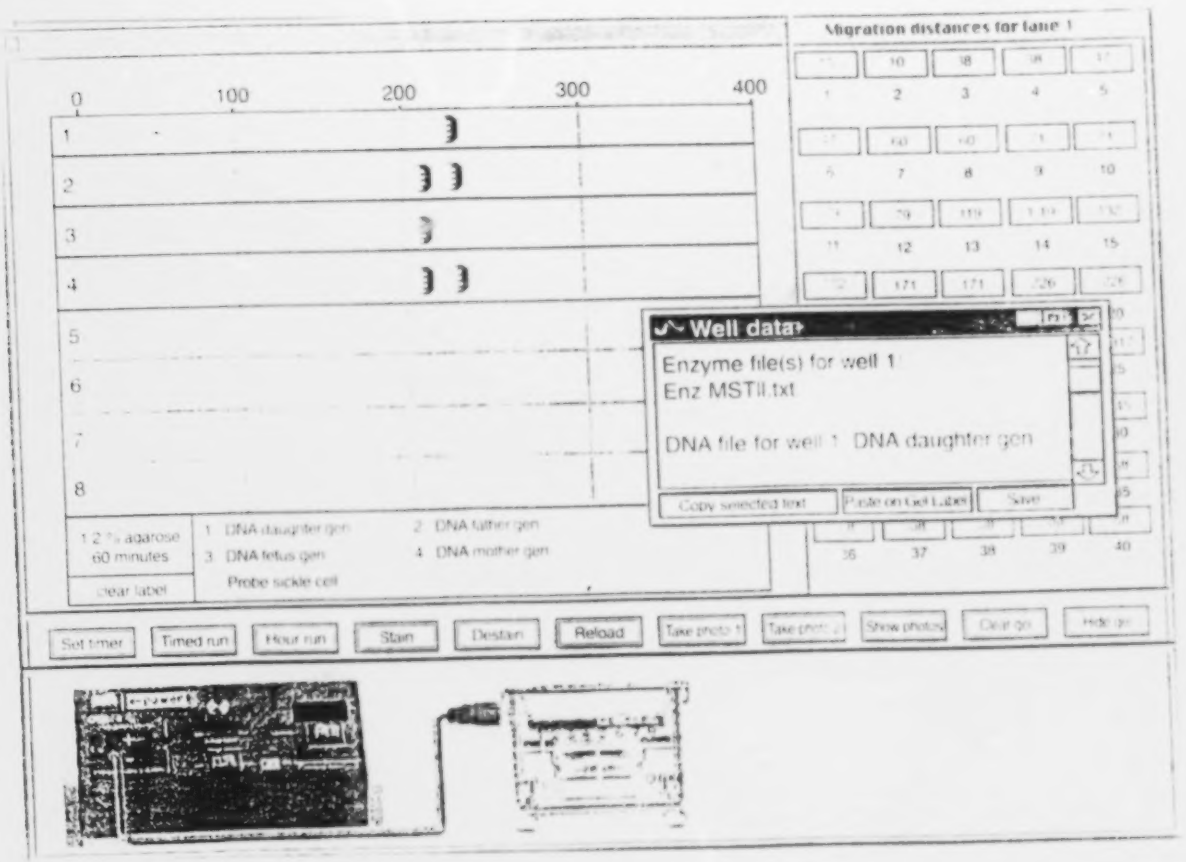
DESCRIPTION OF THE CASE IT! PROJECT

To give students a powerful tool for case analysis, the authors first developed a DNA gel electrophoresis/ Southern blot simulation to analyze any DNA sequence using any combination of restriction enzymes and probes (Bergland, 1997; Bergland and Klyczek, 1998; Klyczek & Bergland, 1996). DNA sequences were obtained for genetic disease conditions from Internet data banks and hypothetical case scenarios were developed for families being tested for these conditions.

Working in teams, students selected a case and used the simulation to test for the presence or absence of disease-associated genes in family members described in the case histories. Students were put into the role of genetic counseling teams preparing to conduct counseling sessions with the "families" involved. They then participated in conventional and Internet-based poster sessions during which faculty played the role of family members asking questions about the disease and ethical ramifications of test results.

The emphasis of class-testing thus far has been on the analysis of human genetic conditions such as sickle-cell anemia, Huntington's disease, Alzheimer's disease, cystic fibrosis, Duchenne's muscular dystrophy and breast cancer. Figure 1 shows a Southern blot for the sickle-cell anemia case. Both parents (lanes 2 and 4) are carriers of the sickle-cell gene, and passed this gene to their unborn fetus (lane 3) but not to their unaffected daughter (lane 1).

Figure 1. Southern Blot from Sickle-cell Anemia Case



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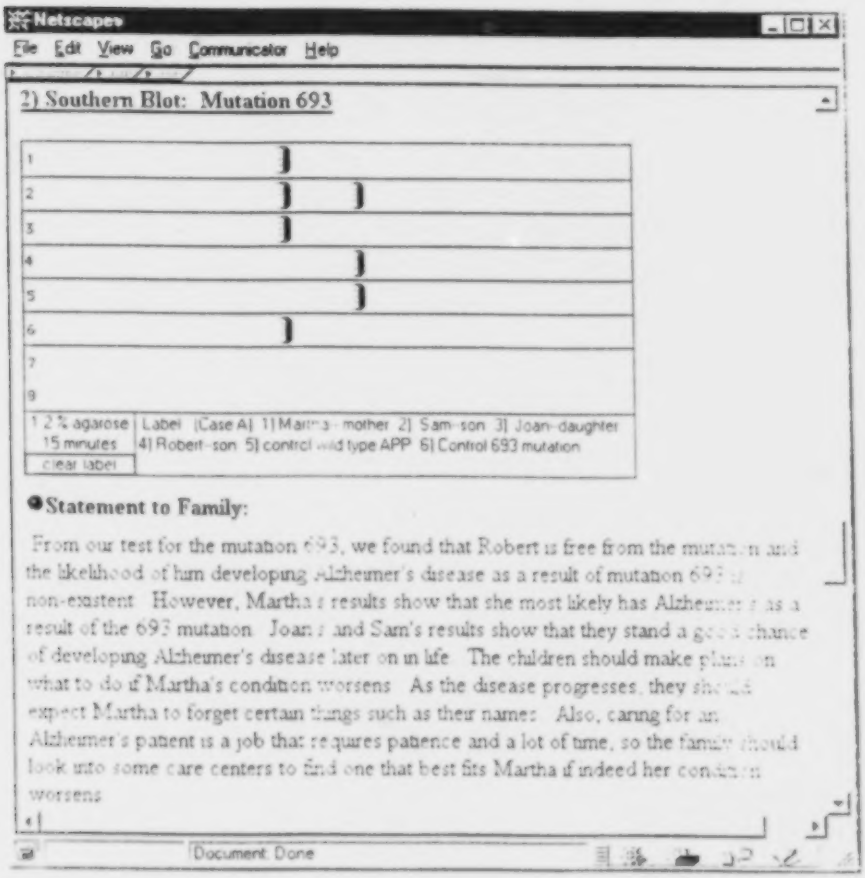
Collaborative teams of students save these types of images and place them on conventional posters or on Web-page "posters" for discussion via bulletin boards accessed from the Case It! Web site http://www.uwrf.edu.caseit/casei/html. For example, Figure 2 is a portion of an actual student Web-page poster in which the implications of Alzheimer's disease are communicated to "family members" (faculty or other student teams).

Figure 2. Portion of Student Poster Web Page


Netscape
File Edit View Go Communicator Help
2) Southern Blot: Mutation 693
1
2
3
4
5
6
7
8
1.2 % agarose
15 minutes
clear label
Label (Case A) 1) Martha - mother 2) Sam - son 3) Joan - daughter
4) Robert - son 5) control - wild type APP 6) Control 693 mutation
Statement to Family:
From our test for the mutation 693, we found that Robert is free from the mutation and the likelihood of him developing Alzheimer's disease as a result of mutation 693 is non-existent. However, Martha's results show that she most likely has Alzheimer's as a result of the 693 mutation. Joan's and Sam's results show that they stand a good chance of developing Alzheimer's disease later on in life. The children should make plans on what to do if Martha's condition worsens. As the disease progresses, they should expect Martha to forget certain things such as their names. Also, caring for an Alzheimer's patient is a job that requires patience and a lot of time, so the family should look into some care centers to find one that best fits Martha if indeed her condition worsens.
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The Case It! Project has recently been expanded so that intra- and inter-institutional teams of students can discuss results with their peers in other states and/or countries. The feasibility of this concept was demonstrated by a pilot project carried out during the spring semester of 1998 in which students at the University of Wisconsin-River Falls interacted with their peers at Westfield State College in Massachusetts. The investigators are now in the process of acquiring additional hardware and developing a new software system so that students from remote locations can easily upload text and graphics to a server at UW-River Falls without having to construct their own Web pages (this would continue to be an option, however).

ASSESSMENT METHODS

Quantitative and qualitative analysis of results indicated that the case-based simulation enhanced understanding of biological principles and ethical issues, particularly for female students. Forty-three students participated in the project during the spring of 1998, organized into collaborative teams of two or three. After running data using the DNA electrophoresis simulation, teams researched the disease and presented their results both at an Internet-based and a live poster session.

During the two-week Internet poster session students asked one another questions and answered questions related to their posters. At the live poster session collaborative teams were placed in the role of genetics counselors, asked to interpret results and to consider their ethical ramifications. Faculty played the role of family members asking questions during the live poster sessions. In addition to examining changes in understanding, confidence and interest, the transcripts of the electronic poster sessions were evaluated and interviews held with 24 students.

Quantitative and qualitative measures included pre and post questionnaires designed to assess students' interest and confidence, as well as open-ended evaluations from all students. In addition, a team of six preservice science teachers (three women and three men) followed twelve students in depth, videotaping them as they worked through the computer simulation, tracking their responses in the electronic poster/conference session and interviewing them at the live poster session. These preservice teachers met weekly in a research seminar to read related literature, design instruments, analyze data and report their case study and interview results.

ASSESSMENT RESULTS

Analysis of pre and post questionnaires for the experimental and control groups indicated that the case-based simulation enhanced interest in biology, significantly so for female students ($t= 3.34$, $p<.003$). Students really enjoyed being able to choose and explore a disease they had heard about in the news, or one which had affected their families. Students also became more confident in their knowledge ($t=7.19$, $p<.0001$), based on analysis of pre and post confidence scores (Lundeberg, Fox & Puncochar, 1994). Moreover, women gained greater confidence on the post-assessment than did men ($t=2.45$, $p<.01$). Students' knowledge and understanding of ethical issues associated with genetic testing and diseases also increased significantly ($t =2.24$, $p<.03$).

Both the live poster session and the electronic poster session had advantages. Students appreciated being able to read other students' posters electronically and give them feedback. Several students commented that they liked being able to present their posters electronically first and get feedback from other students so they could revise their posters before the "live" poster session.

However, not all students gave one another substantial feedback, since some commented on surface features, such as grammar. The authors will attempt to improve directions to students regarding the kind of feedback they are expected to give one another next year.

Because faculty played the role of family members and students played the role of genetics counselors during the live poster session, students were not sure exactly what they would be asked and thus prepared extensively for this experience. Comments from students indicated that since the experience was worthwhile as well as time consuming, it should be required of all students rather than offered as extra credit. This change will be made next year.

Finally, involving preservice science teachers as research assistants had a positive effect on these future teachers. They reported learning more about alternative forms of assessment, educational research, hands-on science activities and the use of technology in science classrooms.

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Note: This project is supported by the Course and Curriculum Development program of the *National Science Foundation* (DUE Grants 9752268 and 9455425). Opinions expressed are those of the authors and not necessarily those of the *Foundation.* Software modules described in this paper can be downloaded at no cost to educators from the Case It! Web site at http://www.uwrf.edu/caseit/caseit/html for both the Macintosh and Windows 95 operating systems. Persons interested in becoming involved in the project should contact mark.s.bergland@uwrf.edu for details.

THE WARRIOR ISLAND GAME:

VIRTUAL COMBAT IN THE

ECONOMICS CLASSROOM

George S. Bohler
Donald P. McDowell
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INTRODUCTION

Students enrolled in principles of economics courses are overwhelmingly non-economics majors. The most common reason given by students for enrolling is that other programs, primarily in business fields, require economics. Consequently it is often a challenge for economics instructors to demonstrate the relevancy of the course content. Since *principles* courses are necessarily weighted toward the presentation of abstract theories and concepts, students may fail to make the connection between these abstractions and their practical application in a non-academic setting.

In searching for ways to win over students to the view that economics is not only relevant but also vital for achieving an understanding of the complexities of business decision-making, a means was sought to combine theory with realism in the form of a game. It was decided that such a game should compel players to discover the relevancy of economic concepts for themselves. This is the objective of *Warrior Island.*

Early Applications of Instructional games

One of the earliest applications of instructional games and game theory to the social sciences was reported by Shapley & Shubik (1954). In their paper the authors described a game which had as its objective the determination of relative powers of members of the United National Security Council. A later publication by Shubik (1959) marked one of the first books to apply game theory to economic modeling.

The first microeconomic textbook to fully integrate games and game theory into standard economic material was published some time later by Kreps (1990). Kreps found that the use of game strategy to convey economic concepts resulted in significant improvement in student retention of key course concepts. More recently, Aumann & Hart (1992) published a handbook in this area. This work marked the first scholarly collection of research data regarding the classroom success of various instructional games and simulations in economics.

HISTORY AND EVOLUTION OF WARRIOR ISLAND

Warrior Island was first conceived in 1993. All iterations from that time to the present have been based on a variation of the "Gilligan's Island" scenario. Student teams control the activities of one hundred shipwrecked castaways on a remote island without hope of rescue for at least a year. The sole object of the game is to produce as much food as possible by the end of the twelfth month. There are specific costs and constraints, with all costs stated in terms of person-days of labor. The incentive to maximize food production is enhanced by awarding grades based almost entirely on this criterion. The team with the most food at the end of the game earns a grade of 100.

During their year on the island, student teams consisting of from one to three players must build shelter and acquire food and water in order to survive. Constraints are placed on all possible sources of food and water, and the players are compelled by necessity to construct capital equipment (plows, nets, spears, canoes) in order to prevent starvation. Each day's activities are recorded on a spreadsheet template and food surpluses acquired at the end of a month are carried over to subsequent months. Students are encouraged to be creative in making their allocative decisions but are also cautioned to avoid constraint violations. During oral presentations of reports, the other student teams thoroughly scrutinize presenting teams because of the competitive grading.

As the game evolved over the years, features were added to the scenario allowing teams of players to enter into contracts, mergers and strategic alliances with other teams. At the midpoint of the game, players may elect to attempt hostile takeovers of their rivals' assets. The strongest groups (those with the highest food surpluses and the highest number of survivors, including allies and merger partners) have the highest probability of success when "attacking" a rival. The attacking team must have a greater food surplus and at least as many survivors as their adversary. The outcome of the attack is determined partly by chance--the attacker rolls a die and the odds of a successful roll depend on the relative strength of their adversary. If the attack is successful, the attacker acquires one-half of the loser's food surplus. The "hostile takeover" option has proven to be the most popular aspect of *Warrior Island* among students.

STUDENT REACTIONS AND EVALUATIONS

Forty *Principles of Economics* students who recently completed the project were asked to answer the

questions on a survey instrument designed by the authors. Fourteen of the questions were designed to measure how well the game helped the students understand or apply certain key economic concepts and principles. Ten questions were designed to measure students' perceptions of the game's value as a component of classroom instruction. The last five questions measured how well the game improved other general business skills.

Table 1 shows that a majority of the students (50–97 percent) either agreed or strongly agreed that the game helped them to better understand and/or apply all fourteen of the basic economic principles.

Table 1. Student Response Regarding Helpfulness of Game to Understanding of Course Content

Items In Rank Order	Percent who "Agree" and "Strongly Agree"
Resource Allocation	97.33%
Scarcity	95.00
Opportunity Cost	92.50
Mergers and Acquisitions	90.00
Contracts	85.00
Comparative Advantage	83.33
Division and Specialization of labor	82.05
Profit Maximization	80.00
Investment	80.00
Supply and Demand	71.79
Benefits of trade	65.71
Capital Budgeting	62.50
Law of Diminishing Marginal Utility	52.50
Law of Diminishing Returns	50.00

Three items on the survey were designed to determine if the game was too difficult. Table 2 indicates that the students clearly did not find it too difficult, although they perhaps found it too time consuming.

Table 2. Student Response Regarding Difficulty and Time Requirements of Game

Item	Percent who "Agree" and "Strongly Agree"	Percent who "Disagree" and "Strongly Disagree"
Too difficult	7.50%	75.00%
Too easy	17.50	70.00
Too time consuming	30.59	47.06

The questions relating to general business skills indicated the game to be valuable to students. This is shown in Table 3.

Table 3. Student Perceptions of Value of Game to General Business Skills

Item	Percent who "Agree" and "Strongly Agree"
Critical Thinking	95.00%
Spreadsheets	89.47
Teamwork	83.33
Delegation of authority and responsibility	78.95
Linear thinking	75.00

SUMMARY AND CONCLUSIONS

The *Warrior Island* game has been successful in increasing student understanding of critical economic concepts. This has been accomplished by allowing students to discover in a game setting how the very act of making decisions compels them to address issues including trade-offs, scarcity, resource allocation and opportunity cost. After their initial shock at the apparent magnitude and complexity of the task, the great majority go on to successfully complete the project. The enthusiasm and competitive spirit that they demonstrate during their

presentations reinforces the positive inferences that can be drawn from their questionnaire responses.

The authors also noted that, in addition to discovering the applicability of the economic principles enumerated above, there were other spillover benefits. *Warrior Island* appears to compel players to think logically and strategically and to consider both the long-term and the short-term consequences of decisions. Also, most students discover the benefits of knowing how to use computerized spreadsheet programs (Lotus and Excel) which will assist them in a number of other business applications.

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INTERACTIVE MULTIMEDIA

INTELLIGENT TUTORING SYSTEM

Brian P. Butz
Temple University

INTRODUCTION

A continual challenge in teaching is meeting the students' academic needs and ensuring that they are active participants in their own education. Over the past decade several studies have been made to detect students' learning styles (Felder, 1996; Lumsdaine & Lumsdaine, 1987; Montgomery 1995; Stice, 1987). These studies conclude that students learn best if they are active participants in their education and are exposed, in varying degrees, to each discerned learning style.

Visualizing the dynamic behavior of physical systems is an important part of the learning process for students (Doering, 1996). Interactive multimedia presents an opportunity for using advanced technology to improve and enhance a student's learning environment (Lee & Sullivan, 1996). Many students are more attentive to visual lessons, seem to retain more of what they see over what they hear and are more comfortable with visual learning. While texts are certainly visual they tend to be static, while computer software and computer networks have introduced students to dynamic visual material that may be modified by the user.

INTERACTIVE MULTIMEDIA

Interactive multimedia software can play a key and unique role in the educational process. It may be used as a stand-alone educational module that is intended to enable an interested individual to learn about a particular topic or subject (Sears & Watkins, 1996). It may be used as a supplement to classroom presentations (Butz, 1997) and laboratories (Mosterman, et. al., 1996), or it may be used as a dynamic textbook (Harger, 1996).

Interactive multimedia brings an additional dimension to on-line learning courses. Such courses, which use the Web to present material, animations, movies and other forms of user interaction, are a growing subset of more traditional distance learning programs. Due to technological advancements, the number of universities offering distance learning programs has increased from 94 in 1993 to 384 in 1996 (Woitena & Parkes, 1996). Many of the newer distance learning programs offer at least some of their courses asynchronously on the Web.

Moreover, interactive multimedia software is currently being marketed as a stand-alone asynchronous learning aid. Examples include various members of the Schaum's Outline Series, an electronics laboratory simulator (Mosterman, et. al., 1996) and a set of introductory calculus modules (Quinney, et. al.,1996). The National Science Foundation has also funded a number of investigators to develop interactive multimedia educational modules or interactive multimedia courseware.

Consequently, it is reasonable to assume that interactive multimedia modules are no longer simply interesting curiosities. It is very likely they will become part of the 'usual' educational process in the foreseeable future, especially as the authoring software becomes easier to use and more powerful, leading to a reduction in the long

development time required for each educational module (Iskander, et. al., 1995).

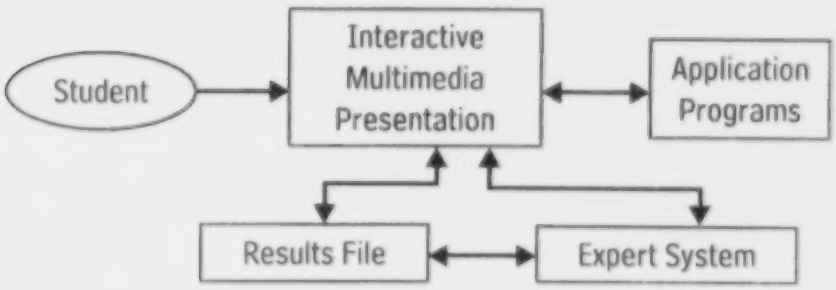
AN INTELLIGENT TUTOR

This paper describes the next logical step in the use and the development of interactive multimedia modules. The questions addressed in the Interactive Multimedia Intelligent Tutoring System (IMITS) project include how interactive multimedia modules can: 1) monitor student interactions with the software; 2) analyze these interactions to determine what the student is learning and is not learning; 3) discern and characterize any flaws in the student's learning process; and 4) interact dynamically with the student to correct any factual, logical or procedural flaws. In other words, the goal of this project is to develop the framework of an interactive multimedia intelligent tutoring system and to demonstrate that it works on several interactive multimedia modules covering various topics in an engineering curriculum.

THE DESIGN OF THE INTERACTIVE MULTIMEDIA INTELLIGENT TUTORING SYSTEM

An overview of the interactive multimedia intelligent tutoring system is shown in Figure 1.

Figure 1. Overview of Interactive Multimedia Intelligent Tutoring System



The student interacts with a personal computer to complete an interactive module. As the student completes the module, every interaction the student makes (every selection, change of selection, computation, etc.) is monitored and recorded. All of this information is available to the expert system. The expert system analyzes the results at appropriate intervals during the interactive session to determine how well the student understands and applies the material presented in the module. If the expert system detects a problem in student learning it may "interrupt" the session by asking the student questions or it may decide to let the module proceed so that it may obtain more information about the student's thought process. If the expert system seeks information from the student it is to clarify a student response or to ascertain why certain decisions were made by the student. Though the questions may be based on the material being learned, no new expository information or modification in the lesson plan is presented at this point.

When the expert system has enough information to determine any procedural or logical flaw exhibited by the student the interactive module is modified. The student continues to interact and is oblivious to the presence of the expert system (the student-expert system interaction appears to the student to be part of the learning module).

The learning module is reformulated until the expert system detects a satisfactory performance in the student's understanding of the material.

If a satisfactory level of understanding is not obtained, the expert system generates a file for the student and another file for the instructor. The student's file contains suggestions for improvement and directs the student to the instructor. The instructor's file contains a detailed analysis of the student's performance for the instructor's use.

The authoring tool selected to develop the interactive modules was *Authorware* (Macromedia, 1995). *Authorware* was chosen because it has a relatively short learning curve for its basic use, is a cross platform tool so it will run on both PCs and Apple computers and the resulting modules can be packaged as executables so that a user need not have a copy of *Authorware* to run modules developed with this tool. Also, using Microsoft's Dynamic Data Exchange, *Authorware* is able to exchange information dynamically with other application programs. The software is also noted for its ability to judge, track and record. The expert systems software used was CLIPS (Giarratano, 1989), a package developed by NASA.

THE IMITS MODULES

The interactive multimedia modules developed must satisfy several objectives. First, the material within each module must be correct, well planned and presented clearly and succinctly. The material must be designed so that the student can not only learn from it but also can be shown aspects of the theory that are particularly explanatory and upon which the student can build.

Second, the presentation must engage the student. Projects and laboratories should be designed with an appropriate use and mix of videos, animations, three

dimensional models, audio and various ways for the student to interact with the material.

Third, there should be certain unifying themes throughout the software. Within IMITS the themes are the engineer's office and the engineer's laboratory. In the office the engineer can find and read files, check books, use e-mail, have access to teleconferencing and use application programs. In other words, the office appears just like a modern engineering office. The laboratory allows the engineer to set up certain experiments to verify designs. The laboratory contains virtual instruments representing modern electronic test equipment.

Fourth, there should be a seamless hidden communication channel between the multimedia modules, the expert system and the various application programs used by the engineer. This dynamic communication procedure needs to be programmed in the background.

The modules should permit the student some choice of actions. While not purely constructivist, the modules should give the student control to choose from a limited set of actions. For example, a student may decide to get additional information to help design a certain device. The student may use e-mail, check the corporate files, use the corporate library, or teleconference. The student decides what information to get and how to get it. Then the student decides how to use the information to attempt a solution to the task at hand. Consequently, the tutor not only helps the student learn the material being taught, but also helps a student learn how to tackle typical design and analysis problems.

CONCLUSIONS

IMITS is an interactive multimedia intelligent tutoring system that assists students learn material by doing. It gives the student various analysis and design

problems and allows the student to decide how to approach, set up and solve the problem. It tutors students to help them master material while showing them a procedure for solving typical design/analysis problems.

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ASSESSING MODELS

OF INFORMATION LITERACY

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INTRODUCTION

The notion of information literacy as a complex generic skill has evolved in the past decade. This evolution has occurred as part of the recognition that undergraduate education involves a process of enabling people to discover ways of learning and knowing about themselves, their physical environment, their beliefs and values (Candy, Gay & O'Leary, 1994).

The relational model of information literacy proposed by Bruce (1997) is claimed to challenge the established paradigm which is described as functional and based on an analysis of expert behavior. The model proposed by Bruce contains seven phases that describe the development of skills in relating to the world. The phases involve use of technology, search awareness, search strategies, information storage and retrieval, evaluating information and creating new ideas, integrating new information with existing knowledge, and ethical valuing of knowledge. To define these phases Bruce defines skills, knowledge and attitudes that identify each phase and which, as a consequence, can be interpreted in operational terms.

Information literacy is a generic skill because it is required of people in many, if not all, occupations and across all aspects of adult life. At higher levels of use, there

has been found to be an interdependency among some generic skills. For instance, in Australia the *Key Competencies* were defined by the Mayer Committee (Mayer, 1992) to include planning and organizing and solving problems. These are found normally to be co-dependent at least at higher orders of functioning. Others, such as using mathematical ideas and techniques and using technology, are not necessarily interdependent (Colvin & Catts, 1996).

It has been argued that information literacy is not amenable to measurement. One argument is based on the claim that like all generic skills, information literacy is domain specific. That is to say that you cannot demonstrate a generic skill in a void. In order for it to be observed there must be a context and hence a specific body of knowledge or practice within which the generic skill is performed. This has led some to argue that there is no such thing as generic skills (Lave & Wenger, 1991). They point to examples where a learner acquires skill in a specific context and is not able to transfer it to a different domain. This, however, reflects deficient teaching strategies and hence limited or surface learning (Catts & Appleton, 1998).

Others have pointed to the complexity of the information literacy construct as a basis for concluding that it cannot be assessed (McCrank, 1992). This argument both ignores the finding that some generic skills are interdependent at higher orders of functioning, and the capacity of factor analysis to define constructs that are interdependent. This paper seeks to identify the constructs that underpin information literacy in order to construct valid assessment tools and to identify implications for teaching and learning.

CONCEPTUAL FRAMEWORK

The relational model of information literacy proposed by Bruce(1997) implies a developmental theory of information literacy acquisition. One way in which the development of information literacy can be conceptualized has been proposed by Daragan and Stevens (1996). Table 1 relates these constructs for development with the seven phases in the Bruce relational model.

Table 1: Comparison of Developmental Stages with the Seven Phases of Information Literacy

Stages of development		Seven Phases Model	
Dualism	knowledge • right wrong model • single source • no evaluation • sources undifferentiated	1 and 2	information is • objective • external • provided
Multiplicative	knowledge • no critical facility • all answers correct • avoidance of new • overload	3 and 4	information is • contextual but objective • part of external context • access from specific sources
Relativism	knowledge • perceived as subjective • sought from multiple sources • is evaluated	5	information is • subjective • an object for reflection • internal to the individual • accessed from relevant sources
Commitment	knowledge • analyzed and synthesized • bias recognized • open to change	6 and 7	information is • transformational of the learner, and • itself transformable • accessed from emergent sources

The analysis suggests a way of conceiving the interdependence of the seven phases of information literacy. The purpose of the present study is to investigate the extent to which the seven phases of the relational model are interdependent.

METHODOLOGY

In the present study, the model devised by Bruce was used to generate 250 items that were thought by experienced academic and library staff to constitute examples of the seven phases of information literacy. These items were edited and then presented to pairs of experts, usually one academic and one librarian, who were asked to assign each item to one of the seven phases. Items that were thought to be ambiguous, or not primarily identified with a specific phase, were rejected. So too were items on which groups of experts differed as to the relevant phase. Of the 250 items, 88 survived this validity check and constituted an item pool. These items are the subject of on-going trial and analysis. Only the first phase of this analysis is presented in this paper. Further items are to be trialed in February, 1999.

Thirty-five of the available items were administered to intact class groups in October, 1998 near the end of the academic year in Australia. Students were informed as to the purpose of the study and data were collected only from those who signed a consent form. Data were obtained from 146 students, but due to changes made during the data collection process to address possible ambiguity with some negative direction items, complete data were available for only thirty of the initial thirty-five items.

The thirty items were subjected to Principal Components Analysis followed by a Principal Axis Factor Analysis utilizing the SPSSX program. In addition, students were offered the opportunity for a half hour

diagnostic assessment with skilled librarians. Twenty-two students accepted this offer and an expert judgement of the information literacy skills of this group was obtained. Total score and component correlations were compared with the scales constructed from the factor analysis, to examine concurrent validity.

RESULTS

The data were first analyzed using a principal components analysis with seven components to test the extent to which the seven phases model was supported. The statistics showed that there were sufficient data for an exploratory analysis. The model accounted for fifty-two per cent of the total variance. The scree plot indicated a definite transition after four components suggesting the possibility of a more parsimonious solution. In the seven component model, four of the thirty items loaded uniquely on the first component at more than 0.4 with no cross loadings above 0.3, and a further seventeen items cross loaded on this component at greater than 0.3, suggesting a generalized information literacy component. The remaining components were not well specified.

In the four component model there were seven items that loaded uniquely on the first component, four on the second component, two on the third and one on the fourth component. The overall pattern of loadings and the number of uniquely loading items, taken together with the scree plot evidence, supported a four factor solution.

A rotated principal axis factor analysis using the varimax solution achieved a four factor solution which accounted for fifty-four per cent of the variance and produced four meaningful factors. The four factors are as follows: 1) one factor termed *Searcher* related to confidence in searching ability and was typified by items such as "I can find relevant information"; 2) a second factor

termed *Organizer* related to management of information, and included items like "I have trouble organizing information I gather for assignments"; 3) the third factor termed *Information User* related to the summarizing, analysis, evaluating and integrating of information and included items like "I draw conclusions after integrating new information with prior knowledge"; and 4) the final factor termed *Technology* was related to the use of technology and included items like "I have trouble using the computers to search for information in the library".

Based on this analysis, a set of four scales were constructed from items that uniquely loaded on each factor. Three 'four item' scales were used and technology was assessed using two items. Correlations between the four scales were examined as was the correlation between each subscale and a combined information literacy scale (excluding the technology items). Complete data were available for 144 of the 146 cases. As reported in Table 2, the correlations between factors are small to moderate suggesting that the four factors can be distinguished in a meaningful manner and thus provide a basis for analyzing teaching, learning and assessment methods.

Table 2: Correlations among Four Factors of Information Literacy

TABLE 2: CORRELATIONS AMONG FOUR FACTORS OF INFORMATION LITERACY

FACTOR	SEARCHER	INFO USER	ORGANIZER	TECHNOLOGY
SEARCHER	1			
INFO USER	.25**	1		
ORGANIZER	.31**	.13	1	
TECHNOLOGY	-.20*	-.12	-.23**	1

** significant at the 0.01 level (2 tailed)
* significant at the 0.05 level (2 tailed)

The correlation between the *Technology* factor and the composite information literacy scale, formed by combining the scores on the other three factors, was 0.01. This supports the view that the *Technology* factor can be considered separately to the other components of information literacy.

An expert assessment of information literacy was available for twenty-two students. These assessments were based on the seven phases relational model, with the aim of maximizing the opportunity for consistency between the self report inventory and expert judgement. The correlations between the factors and the librarian assessments for the phases that most closely approximate these factors is presented in Table 3.

Table 3: Correlations between Expert Assessment and Performance on the Four Factor Information Self Report Inventory. (N = 22)

TABLE 3: CORRELATIONS BETWEEN EXPERT ASSESSMENT AND PERFORMANCE ON THE FOUR FACTOR INFORMATION SELF REPORT INVENTORY. (N=22)

FACTOR	INFO USER	SEARCHER	ORGANIZER	TECHNOLOGY
PHASE 5 TO 7	0.59 **			
PHASE 2 TO 3		0.25		
PHASE 4			0.13	
PHASE 1				0.20

The relationship between Phases 5 to 7 of the relational model and the *Info User* factor is substantial. The other results are less satisfactory and require further elaboration.

DISCUSSION

The proposition that was investigated in this study was that a four factor model would account for the seven relational phases of information literacy (see Table 1). A four factor model has been identified that is consistent with

both the original relational model and consistent with, but not identical to, the postulated four factor model.

Two of the seven phases appear to be separate generic skills which correspond to two of the Mayer *Key Competencies* namely *Using Technology* and *Planning and Organizing*. Using technology in an information literacy sense encompasses use of computers to search for information from library catalogues, networked databases and the Internet and may include other technology such as microfiche readers. There is a modest relationship between using technology and both *Searching for Information* and *Planning and Organizing* information, but no relationship with *Using Information*, which perhaps enters a more creative metacognitive domain. Overall there is a zero correlation between these three factors combined and the use of technology. Thus, while the ability to use technology is essential in order to collect and manipulate information, this factor is statistically independent of information literacy.

Planning and Organizing has been identified as a separate factor in this analysis. It correlates with both *Searching for Information* and *Using Technology*, but does not correlate with *Using Information*. Only *Searching for Information* correlates with *Using Information*, thus suggesting a hierarchical relationship in which using technology is a prerequisite skill, *Planning and Organizing* is an enabling skill and *Searching for Information* and *Using Information* are complementary factors in the information literacy construct.

This analysis differs from the postulated four factors and calls into question the developmental assumption that appears to underpin the model proposed by Daragon & Stevens (1996). The model proposed here assumes prerequisite and enabling skills that enhance the growth of information searching and use.

One possible explanation for the difference between the developmental model and the observed four factor model is that the model postulates development over time, whereas the data provide for a functional analysis of information literacy at a particular point in time. Were all the learners at the same stage of information literacy, then the data would not enable the developmental model to be identified. The judgement of experts suggests however that there is a wide spread of development of information literacy in the respondents. It would follow therefore that some are largely operating at each of the four stages of development and that therefore the model should be reflected in the data across subjects.

CONCLUSIONS

This paper reports a preliminary analysis. Results will be compared by gender, by course of study and by location of home, to test for systematic bias or variation. Results will also be correlated with grade to determine whether the predicted relationship between information literacy and GPA is found.

The initial analysis provides a possible direction for focusing information literacy teaching programs. Information literacy may be addressed by first securing technological competence and by enhancing planning and organizing abilities. To be effective these skills need to be built into the first year curriculum. Information searching skills and information use to analyze, evaluate and form new knowledge appears to depend upon these *Key Competencies*. Structural equation modeling should allow these hypothesized relationships to be explored.

Information literacy is amenable to measurement and initial data suggest that a four factor solution is sufficient for assessment of the effects of curriculum and teaching initiatives on learning.

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ELECTRONIC PORTFOLIOS:

APPLICATIONS IN STUDENT ASSESSMENT

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INTRODUCTION

In the year 2001 we anticipate that the majority of students receiving an undergraduate or graduate degree in institutions of higher education will document proficiency through an electronic portfolio. As Boyer stated, "it is imperative that we link effective classroom teaching with documented evidence that our students have learned." (Boyer, 1995, p. 2). Effective university teaching in the 21st century will require postsecondary institution faculties to integrate technological elements that facilitate knowledge transfer into their instruction (Chambers et. al., 1992).

In this paper, the author discuss effective use of electronic portfolios and how this technology will assist this transfer by enabling students to document what they learn and to assess the impact on their lives. Included in this paper are points to consider prior to adapting portfolios for use in the classroom.

Technology and Portfolios

The role of technology in portfolio development and assessment of student learning must be analyzed. The

electronic portfolio provides a unique opportunity to assist students with both professional and personal growth. Two major research questions central to documenting portfolio use are: *What roles can technology play in authentic assessment of undergraduate and graduate students?* and *How does this relate to Web site use?*

According to Wiggins (1989), assessment is authentic when we directly examine student performance on worthy intellectual tasks. Traditional assessment, by contrast, relies on indirect or proxy 'items'--efficient, simplistic substitutes from which valid inferences seldom can be made about the student's performance on learning tasks. Wiggins further elaborated by stating that authentic assessment is labor intensive, time-consuming and expensive. Meyer (1992) clarified the difference between performance assessment and authentic assessment by asking *who has the locus of control?* In authentic assessment the student completes the desired behavior in a real-life context. The student determines the topic, the time allotted, the pacing, and the conditions under which the examples are generated.

Technology can be employed by both the student and the faculty member to improve performance and instruction. It provides a means for students to reflect on authentic tasks that will be part of their professional life. Faculty can enhance their instruction and lessen their workload by taking advantage of the unique capabilities of various technologies for reviewing student work and transmitting comments to the students.

The utilization of technology in higher education has been minimal, even though technology has been evident by "use of classrooms and labs emphasizing 'hands-on' computer-based drill and practice exercises" (Chambers, et. al., 1992, p. 292). Modern electronic classrooms encourage a change in faculty roles by supporting monitoring, stimulating and facilitating

discussions among students. The newer electronic classroom "blocks out outside stimuli and presents situations as realistically as possible, short of the use of virtual reality; thus students are projected into meaningful situations in which learning occurs faster due to the focus of attention" (Chambers, et. al., 1992, p. 293).

DESCRIPTION OF THE COLLEGE PORTFOLIO PROCESS

For the last five years, the undergraduate and graduate students in Library Media, Educational Leadership, Computer Education and Teacher Education at Wright State University have been required to construct a portfolio as a culminating activity. This requirement has evolved into a portfolio document and presentation that represents an array of knowledge, performance and values developed by students during their degree work.

Students entering these programs are required to take an entry course that introduces them to a specific program of study, expectations of the department, library resources available to them and the basic structure and requirements of the electronic portfolio they must complete by the end of their program. In the last quarter of their studies, students present the portfolio. Having a common entry point has proven beneficial as students begin to bond with other beginning students, questions are asked and answered, the departments have the opportunity to detail expectations and a mind set is created about the development of the portfolio.

Students are instructed on how to use critical reflection and are encouraged to do this as their program progresses. The exit class is usually smaller than the entry class and by this time most of the students know each other and end up as sources of support and assistance.

An introduction to the electronic portfolio occurs and students are asked to perform tasks and demonstrate content knowledge and skills, some of which are videotaped and available for inclusion in the portfolio if desired. Students learning how to do research and explore reference tools quickly find and depend on *Internet* sources both in-house and throughout the world. Instructors have the opportunity to share in these explorations electronically, through "chat" modes, discussion groups or by reviewing findings via e-mail. Media and television production classes permit and encourage students to create materials that will support their professional work. Telecommunications coursework engages students in actual distance learning activities and involvement in a variety of delivery modes.

Digital and optical media are part of all programs of study. Understanding how laser video disks and CD-ROM disks work in reviewing video-based materials is critical. College departments have yet to create their own optical media, but list this as a future goal.

As the graduate students' programs progress, video tape is used for reflection and the development of instructional materials. Students and faculty check-out camcorders and tripods to video tape activities in classrooms, media centers, computer labs and other educational facilities. Digital cameras and computers with the capability to digitize video are also available for visuals that can be added to multimedia presentations or Web pages.

As technology evolves, so does the variety and depth of user change. Students now use video editing equipment to assemble videotape or digitize video clips for inclusion in the electronic portfolio. Examples of lessons taught, interviews, papers written and skill-dependent tasks are easily included. Student accounts on the university

network allow for electronic submission of assignments and faculty electronic office hours.

In assessing students, issues of time spent, cost and labor are shifted onto the shoulders of the students rather than remain focused on the instructors. Instructors are now able to spend their time in valid and reliable tasks such as viewing and analyzing video taped excerpts of an intern's day, sharing in the joys and frustrations of online reference searches, critiquing newly produced materials and coaching students in developing reflective writing skills. Faculty and students electronically engage in the oral analysis of research, collaborate on solutions to real problems and together gain confidence in meeting performance obligations.

TECHNOLOGY HARDWARE AND SOFTWARE

Specific technologies used in Wright State's undergraduate/graduate programs to develop the electronic portfolio include:

- Video camcorders and editing equipment.
- Up-to-date Macintosh and PC computer workstations and labs equipped with laser and ink-jet printers, scanners, digital cameras and video/audio digitizing cards.
- Access to Ohio Link which provides state-wide access to library resources.
- Access to over a thousand educational and other computer software programs.

- Online computer services like *America On-Line*, *Prodigy*, *CompuServe* and *Internet*.

- Access to video disk players and a growing collection of video disk and CD-ROM programs.

- Access to an educational resource center with a media production lab, an instructional materials collection, a microcomputer lab, and a professional reading area.

- Students are provided an account on the University's network that enables them to use e-mail, access to *Internet*, access to the campus libraries and accessing information and people in remote locations.

- Opportunities to create and mount personal Web pages on a university server.

- Electronic resources from the university's libraries include remote searching of databases with access to many full-text databases of current research publications.

CONCLUSIONS AND RECOMMENDATIONS

It is now possible to evaluate exit outcomes and areas of the curriculum that were previously not assessed. Traditional testing tends to "over assess student 'knowledge' and under assess student 'know-how' with knowledge" (Wiggins, 1992, p. 704). Students are now able to use technological knowledge and skills to demonstrate learning impact and document growth. Course assignments

and class activities are designed to support a variety of approaches, learning styles and solutions. Technology provides simulations and examples that are realistic in context, thought-provoking and engaging.

Technology can assist in the development of testing activities that can be designed to replicate constraints and opportunities encountered in real-life professional situations. Using the International Society for Technology in Education (ISTE) guidelines for technology competencies for all teachers, it is possible to review programs of study for planning educational applications of technology in teacher education curricula. Even though these guidelines refer to basic teacher knowledge, skills and attitudes, other educational programs could find them useful in establishing instructional outcomes and determining assessment practices.

Consideration should be given to emerging technologies that support authentic assessment. The Web provides an interactive, fluid environment that supports continuous portfolio development. Current technologies such as video tape, CD-ROMS and multimedia packages tend to be static and unchangeable once completed. Web pages are agile and easily added to--the flexibility and immediacy of the medium are perhaps its greatest strengths. Issues related to Web pages include capacity-level of computers used, availability of a server to host the pages, technical knowledge and skills of the assessors and developers and copyright, privacy and professional impact topics.

Higher education faculty, along with the rest of society is racing into a future continually shaped by technology. Predicting technology's impact on undergraduate education programs might be done by examining trends and innovations. This task is not finished and along the way faculty must deal with issues of what it means to provide a positive climate for learning, how to support and

enhance faculties' new roles, determining what are appropriate authentic activities and understanding how best to empower our students by helping them set personal and professional goals, allowing them to work cooperatively and to engage in self-evaluation and reflection on their performance, progress and products. Through such efforts students will be ready to merge into the "global village" and use the electronic portfolio as a viable learning experience.

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DIGITAL PORTFOLIOS:

ISSUES AND SOLUTIONS

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INTRODUCTION

Both employers and professors urge students to prepare portfolios to demonstrate their writing skills and to document what they have learned. This paper provides a format that may satisfy both agendas. The literature suggests generalized guides for portfolios. They should mirror professional communication (Slick, 1997; Weimer, 1998) and should connect theory to practical job needs (Boulware & Holt, 1998; Lankes, 1998; LaPlante & Springfield, 1997; Pack, 1988).

The Communication Department at the University of Toledo sought more specific guides for its undergraduates. Specifically--*what will employers actually read and what can teachers actually grade?* In focus group sessions, employers advised--if portfolios could narrate the client's perspective with respect, student authors would tower over most applicants. But, employers stated, student portfolios were often poorly organized, bulky 3-ring scrapbooks, stuffed with academic tokens of little interest to the employer.

The faculty also had specific assessment needs. Too often students assumed portfolios were stream of conscious diaries. Faculty wanted portfolios organized around clear learning levels--*what do faculty want students to demonstrate?* It was decided that students' portfolios must demonstrate Thomas Angelo's (1991) four levels of learning: 1) Declarative Learning--mastery of facts and

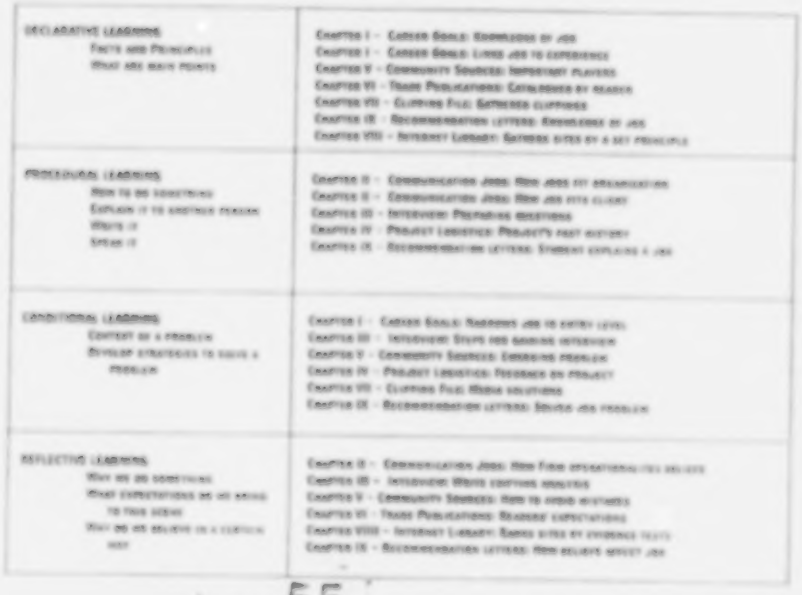
principles and ability to extract the main points from a document; 2) Procedural Learning-knowledge of how something is done and an ability to explain it; 3) Conditional Learning--comprehension of a problem's context and ability to develop solutions; and 4) Reflective Learning--understanding of the expectations self and others bring to a job and an ability to provide a rationale for those beliefs.

A second faculty need was--*how will the portfolio be organized?*

PORTFOLIO GUIDELINES

In order to meet employer, student and faculty needs, the faculty identified nine chapters to be completed by students. Multiple versions of these chapters were assigned in communication courses. At the end of the junior year students had at least three essays under each chapter heading. Seniors created portfolios by selecting the best essay in each chapter consistent with a job interview, assembling the essays on a disk and taking it to the interview. Table 1 summarizes the chapters.

Table 1. Evaluation Grid



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Descriptions of the Chapters

Chapter I: My Career Goals: What I Want To Learn At This Firm. Here students' essays connect their professional goals to the specific, entry-level jobs in the target firm. Students demonstrate Declarative Learnings by showing how they surveyed job descriptions, researched the range of entry-level jobs offered in that profession, and demonstrated how their class assignments or internships fit those requirements. Students demonstrate Conditional Learning by writing about ways to solve problems inherent in entry-level jobs.

Chapter II: Communication-Related Jobs At This Firm. Writings in this section focus on Procedural Learning--how entry-level jobs fit into the firm's larger production needs. For example, a student might write about how an in-house newsletter must pre-publicize a new company merger to help prevent charges of "surprise take-over" by workers, trade unions or stockholders. Reflective Learning is demonstrated by writing about how a firm might publicize a specific product's usefulness to the client and community.

Chapter III: Interviews With Professional Leaders And Employers. For this chapter, students identify community leaders from their target profession, obtain appointments to interview them, pose intelligent questions to them and write analyses of the interview in a diplomatic manner. This illustrates Procedural Learning-students had to make interview appointments, explain reasons for the interviews and connect a boss' answers to course content. Conditional Learning--students had to solve the diplomacy problem--how to write fairly about an interview knowing the essay might be read by a competitor. Reflective Learning--could students describe the values of the host interviewer, i.e., what a firm eschews and/or embraces?

Chapter IV: Case Study: Logistics Of A Major Project. Students identify an in-house project at a target firm--how a TV station migrates from a DOS system to a Windows system, or a civil defense drill at a chemical plant. They interview the project director and write a step-by-step explanation of the project. The chief learning levels are Procedural--students explain their understanding of the sub-steps in a major project; and Conditional--students catalog feedback techniques on how to assess the project's success.

Chapter V: The Firm And Community Cooperation. Students write about their knowledge of how community businesses, services and social agencies depend on each other in a community. If students can demonstrate their appreciation of the communication web a firm spins out over the community, they also demonstrate their knowledge of how important community team work is to a firm. Students document these interdependencies by shadowing a public relations mentor for a month and writing an analysis of these contacts. Specific to this chapter, students locate key community "players" in the community drama (Declarative Learning), they learn the contingencies of how each profession links to other professions (Conditional Learning) and they learn how key players motivate these contacts to cooperate with a firm (Reflective Learning).

Chapter VI: A Library Of Trade Publications. Students document their knowledge of trade publications relevant to their target professions. They write an essay 'What Publications I Would Carry On My Bookshelf If I Worked For This Firm.' In it, students gather a full range of publications and abstracts. Here students display Declarative Learning--different trade publications use different principles of communication; media-centered like *Wired*, or reader-centered, like newsletters, or issue-centered like the *Wall Street Journal*. Reflective Learning--

students interview editors of these publications, learning their sources of information and how they perceive audiences' needs to receive that information.

Chapter VII. Clipping file. Students' clippings of news stories are digitized and accompanied with abstracts to demonstrate their understanding of the international, national, state and local press views of a public issue affecting a firm. A clipping file shows Declarative Learning --students gather clippings and arrange them by a given principle or organizational technique. Conditional Learning -- students must give an account of how they see a solution to the problem emerging through the arena of mediated public opinion.

Chapter VIII: Internet Library: My knowledge Of The Internet Relevant To The Firm's Needs. By assembling a library of Internet "hits" students demonstrate Declarative Learning--what principles are used to sort out the myriad of "hits" a search engine may produce. Students create a hierarchy of sources dependent on the quality of information provided. Such a ranking shows employers how the students evaluate Internet sites against the classic tests of evidence (clarity, verifiability, accuracy, etc.). Reflective--by giving a site ranking scores, students can demonstrate if sites are consistent with the beliefs and values of an organization.

Chapter IX: Letters Of Recommendation. Students ask former employers for descriptions of specific skills rather than generalized statements. Employers supply Declarative anecdotes: (a way the student could recall details of a job, such as clients' names and faces). Procedural anecdotes (how well a student explained a new process to a co-worker). Conditional anecdotes (how the student solved a problem in the organization) and Reflective anecdotes (a story that illustrates the beliefs the student brought to the scene). These anecdotes are digitized and included in summary essays.

CONCLUSIONS

How were these changes received by employers and students? A majority of employers sent positive reactions to the changes:

> *The portfolios I've seen seem so tailored to our firm that the candidates had a subtle yet decisive advantage over other fresh-out-of-college candidates.*

On a five point scale (five being high), employers gave the system a mean score of 4.3. The departmental faculty generally agreed with the procedure. One professor wrote:

> *This is an innovative final exam. Students who mastered the topics in class could display their learning on four levels. Students who were incapable of college work needed to repeat the portfolio exercise.*

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DEVELOPING A DISCOURSE COMMUNITY:

TEACHING BIOCHEMISTRY USING THE

WORLD WIDE WEB

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INTRODUCTION

The dilemma is how to get university students actively engaged in learning science. Within the positivistic paradigm the teacher delivers the knowledge in nicely organized lectures with the students sitting passively in rows, taking notes, and often memorizing the material for tests. The teacher may connect to the students' prior learning, but often just begins where the teacher expects that the students should be in their thinking. The problem, of course, is that the students must start with their current understandings. Therefore, if the material presented does not connect to the students' prior understandings, the students may just memorize to pass the examinations. The question is, "Do the students really learn?" when they are mostly passive in the traditional university classroom. Some students will learn any way they are taught, but how can we engage more students actively in learning science?

Recent research has suggested that getting students involved by co-participating in a discourse community (Tobin, 1997) with the students and teachers using the language of the discipline, may help get students to learn (Lemke, 1995). To understand why it is important for

students to engage in discourse in the discipline, it is necessary to understand how we come to know.

The instructor's working theoretical framework for how we come to know is constructivism. Constructivism is "a theory which asserts that knowledge is not primarily received, but actively built and that the function of cognition is adaptive and serves the organization of the experiential world" (Glasersfeld, as quoted in Leonard, p. 9, 1997). Ernst von Glasersfeld extended his ideas further on constructivism when he stated, "Knowledge refers to conceptual structures that epistemic agents, given the range of present experience within their tradition of thought and language, consider viable" (Glaserfield, 1989, p. 124). By students using the discourse of the discipline and listening to their peers use the language of the discipline, each student had a testing ground for their ideas, of trying to make their ideas viable.

ACTION RESEARCH STUDY

In fall '98, the author conducted an action research study in her senior-level biochemistry undergraduate classroom. Action research has been done more by K-12 teachers (Spiegel, Collins & Lappert, 1995; McDonald & Gilmer, 1997), but is starting to be conducted by university faculty as well (Gardner & Ayres, 1998). This Web-enhanced class met three times a week for 50 minute class periods for one semester. The instructor's goals were the following:

Encourage the students to be active learners.

Connect to the students' prior learning.

Provide a learning environment in which the students gain an overall perspective of biochemistry.

Have the students teach and learn from each other in collaborative groups.

Have the students learn the power of using the Internet as a source of up-to-date information on biochemistry.

Have the students learn how to develop Web sites on topics that students selected to study in depth.

Encourage students to reflect on their personal goals for the course and on their learning using an electronic portfolio.

LEARNING THE TECHNOLOGY

Basically, there were two course Web sites, both password protected. One developed by the university called Web-MC, contained a course homepage, syllabus, class schedule, specific resources for the class, assignments, rubric for assessments, communication links and help resources for use of the Web. The second Web site, *Connecting Communities of Learners* (Tobin, in press), provided a site where each student posted answers to end-of-chapter questions and reflected on his/her goals and contributions to the group Web sites, within an electronic portfolio.

In the beginning of the course, some time was spent learning the technology, as most students did not know how to use the Web as a search engine and most had never developed a Web site. By the middle of the semester,

students developed an expertise in technology, often with the help of other students in their collaborative group. In a typical week, the instructor taught one or one and a half class periods, with collaborative groups presenting the rest of the time. The teacher in her lectures, often tied to what the students had presented earlier.

COLLABORATIVE GROUP WORK

Students working in collaborative groups developed specialized Web sites, using a chemically oriented biochemistry textbook (Matthews & van Holde, 1996). Ten collaborative groups (of two or four students each) made group presentations for three of their ten Web sites to the other students in the class.

For each presentation, students peer assessed each other's Web site presentations and self assessed their own presentations. This was accomplished using a form developed by the instructor and presented in Figure 1 on the following page. The instructor collated the results, including her own comments, in typed format and distributed them to each member of the presenting group within a week. Students felt that this feedback from others helped them improve in their presentations. It also made them aware of what makes a presentation better, as they assessed each other's presentations.

Figure 1. Group Evaluation Form Of Web Site Presentation

Name of student presenters:
Presenters' Topic:
Date of presentation:

Write a sentence on your group's response to each question, and using the following rating scale:

4 excellent
3 very good
2 good
1 weak
0 poor

What was your interest in the material presented?

How did the presenters encourage you (and others) to get involved in the presentation?

What new information did you learn that you could integrate into other material learned in the course?

What resource information (i.e., Web site links, other resources) was shared with the class?

What is your overall evaluation of this group's presentation?

Additional comments

WHAT WORKED, WHAT DIDN'T

The class completed the same number of chapters as did a parallel section of biochemistry using an all-lecture

format. Both classes used the same textbook during the same semester. The teaching assistant for the course developed a table of 100 Web sites that the students created, with active hyperlinks that allowed students to link to all the Web sites that all collaborative groups developed (Armstrong, 1998).

What worked best in this course was that the students learned much more in-depth knowledge than if it had been a traditional all-lecture course, as evidenced in their group Web sites and their individual electronic portfolio entries. The students engaged in the discourse of biochemistry in their Web sites, portfolio writings and oral presentations. They selected topics that tied to their career goals and interests, as indicated in Table 1 on the following page.

What did not work well was student frustration during the first few weeks as students tried to learn to use the Web while they were simultaneously trying to learn biochemistry. The instructor did not think she could afford to spend more class time teaching students how to use the Web or the course Web site during class time, if the students were to learn the biochemistry. However, one extra laboratory session per week was scheduled that some students attended near the beginning to help with the technology. By the middle of the semester, students were more comfortable using the Web and developing Web sites.

Table 1. Examples of Topics Selected by Students for Group Web sites on Biochemistry

Metabolic diseases
Metabolism of ethyl alcohol
Human Genome Project
Nuclear Magnetic Resonance
HIV envelope glycoproteins
Elastin
Collagen
Cell-surface carbohydrates
Glycolipids
Keratin
Effect of exercise on mitochondria
Allosteric enzymes and effectors
Vitamins and cofactors
Photophosphorylation
Evolution through cytochrome c
Cytomatrix
Neurons and neurotoxins

The instructor gave an anonymous questionnaire to all the students during the last week of classes to get additional feedback, of both a quantitative and qualitative nature, on what worked and what did not work in the course, from the students' perspective. The objective was to help in preparing for the next offering of the course. It will be interesting to see how the students from the Web-enhanced course compare with those from the all-lecture course in the second semester part of the course.

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COMPUTER-MEDIATED CRITICAL THINKING:

THE VEE HEURISTIC

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INTRODUCTION

One of the more onerous challenges a "techie" in a humanities division must face is showing that computer-mediated teaching and learning can encourage critical thinking and can be worth the time it takes to learn the computer tools required (Jamieson, et. al., 1996). The literature lesson presented below, which can be adapted across the curriculum, is a good response. Students use the drawing tool to divide spaces on the screen. They insert text-boxes and hot-links to name those spaces and to define relationships among the spaces using a cognitive skill essential to comparison--working from the known or more familiar, to the unknown and applying ways of knowing the more familiar to ways of inquiring about the less settled.

For this project the author adapted the Vee heuristic tool described by Nowak and Gowin (1984). The Vee heuristic, first developed for science lab reports, helps students to assess values: "A good piece of knowledge should embody all elements of the Vee, illustrate how those elements are connected to each other, and be coherent, comprehensive, and meaningful" (Nowak & Gowin, 1984, p.109). Students were invited to evaluate it in their learning journals. One student said:

I started recording my ideas in the Vee-tool because it helps me remember what I read. Sometimes reading gives me one idea, but then the class makes me change my mind. I needed a way to keep track.

Another student despaired:

Where do you come up with this stuff?

THE LESSON

Gowin developed the Vee heuristic "to illustrate the conceptual and methodological elements that interact in the process of knowledge construction" (Nowak & Gowin, 1984, p. 3). The vee-shape was chosen because "at the point of the Vee are events or objects, and this in one respect is where knowledge production begins" (Nowak & Gowin, 1984, p. 5). The fundamental questions that direct the interplay in the center space are concerned with two issues: *What do these things that we are observing mean?* and *What is special or significant about these events and/or objects?* (Nowak & Gowin, 1984, p. 112). Figure 1 shows how these elements are mapped in space.

Figure 1: Nowak & Gowin's Vee Heuristic Template

Nowak and Gowin's (1984) method of getting students to 'lay the Vee' on claims involves prompting learners to review what they know about the concept or object using a range of conceptual positions, including world views, philosophies, theories, principles, constructs, and definitions. Gowin calls this conceptual (left) side the 'thinking' side.

Students then engage in focus questions (usually questions that the discipline values in making meaning) to discover values. They sort their findings into four categories--value claims, knowledge claims, transformation, and records--on the 'doing' side.

The author adapted this tool to the computer-assisted composition classroom to help students process information that is provided in an unfamiliar format and context. First, a brief list of focus questions is provided. The student copies and pastes a selected topic in the box at the tip of the vee. Then the student selects a brainstorming activity to discover essential questions that must be answered prior to developing a response to the focus question.

Working alone or in pairs, students map the piece of literature to sort the background information, which they place on the left side of the vee, from the central issues, which they sort on the right. This activity requires a number of interpretive strategies. After students examine the focus question to assess its necessary components, they work through the elements in their own order, perhaps starting with what they know and moving through areas that are confusing. Thus they are involved in actively questioning and using what they know to solve for what they need to know. Group members ask questions when they decide they have hit an insurmountable barrier and they stop when they can answer their own questions and respond to the teacher's.

An Example. For homework, the class read Maya Angelou's (1997) short story "Grandmother's Victory." The story is told from the point of view of a narrator who remembers an incident in her grandmother's store. Several white adolescents harass and provoke the grandmother, a black woman who maintains her poise and grace. The narrator learns a lesson about racial struggle and the integrity of her family.

The composition lesson began with students using Microsoft Word. They opened a file in which the teacher had entered these questions: *What does the title mean? What is the purpose of the background details in the beginning of the story? In what way does the raked-dirt design change significance when the girl rakes the yard for the second time?*

Using the overhead display, the author walked students through the process of drawing the vee-tool in Figure 2.

Figure 2: Student-Generated Heuristic Vee

Teaches them to be clean and respectful, no matter what!
Background Information
Central Information
Who is the grandmother (is she the narrator's mother or really her grandmother)?
What did she eat?
Why did she lose?
Why did she win (what did she do to beat the other)?
What's in the main story
Setting - A small town in the south at the turn of the century
The grandmother can't do anything in this setting, but she prepares her kids for better things
Focus Question: What does the title mean? Grandmother's history means that she believes her kids will be stronger than the poor white trash kids. She believes that God protect people who are clean and respectful. Her kids are and there (sic) kids aren't, so God is going to take care of them.

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The learners cut a question from the document and pasted it in the focus question box. Then students brainstormed related questions and refined their heuristics. Students 'worked the circle'. For example, they answered *Who is the grandmother?* in terms of narrative view, characterization, setting, plot, theme and imagery.

The author prompted students to work quickly, sketching out the connections they had made in brief bullets and inserting textboxes as needed. They were invited to switch from drawing to word processing, to Internet documents or Daedalus discussion, and back to drawing if that helped. As their text boxes became crowded, they were encouraged to use the "paint" formatting characteristics like font and color to group ideas.

DISCUSSION

The tasks described above work on a number of levels. The students are as self-directed as they want to be, and they are having fun. The example shows that students played with different kinds of call-out boxes and lines, but the play was meaningful. When they discovered a new shape they wanted to try, they also found out that they had to fill the shape with something. Moreover, students learned about the recursive nature of prewriting. They started with a structure and worked through the circle, going back over difficult points, knowing when to stop, and asking questions of each other and of the instructor. They had time to sort out ideas and to experiment with relationships among their discoveries. But the most important benefit of this task may have been in providing the opportunity for students to come to their own conclusions.

One student wrote in her learning journal:

English teachers tell us that they want our opinions, but every time we give our opinion, they tell us that we're wrong.

CONCLUSIONS

The vee lesson, in encouraging students to be conscious of the choices they make in processing information, fosters critical thinking through exercising skills in analysis, synthesis, and evaluation of knowledge. Through mapping and active inquiry, learners define what is known and solve for the unknown. Moreover, the lesson plan incorporates a range of diverse tasks that include solitary, self-directed and teacher-directed activities as well as work in small groups and among members of the whole class.

A computer-assisted environment can provide opportunities to match a range of sociological and psychological preferences. The instructor can design activities that can be assessed through strengths in global or analytic perspectives (including preferences for random, sequential, concrete, or abstract material), in multiple intelligences and through action or reflection. In terms of writing, students learn how language patterns make meaning and how prewriting allows writers to refine patterns and to focus lines of reasoning.

In the kind of active learning that is facilitated by these mindtools, "the teacher must change from purveyor of knowledge to instigator, promoter, coach, helper, model, and guide of knowledge construction" (Jonassen, 1996, p. 261). The heuristic vee is thus a kind of 'scaffolding' tool, a mechanism that allows the instructor to perform or support parts of a task until the students' skills are adequate to taking on the whole of the task. This lesson affects their

writing not through mimesis--instead, the students are observing and transforming new strategies for planning to write for a reader who might also look for patterns and connections.

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STORYTELLING TECHNIQUES

IN THE TEACHING OF

MATHEMATICS AND COMPUTER SCIENCE

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INTRODUCTION

Mathematics and computer science, by their very nature, are disciplines that are rich in facts and information. Even so, they are disciplines that could benefit from the infusion of storytelling techniques, providing students with additional means of accessing this information and enriching the educational process as well. This is accomplished by structuring lessons as *story-lessons* that convey information via alternative modes of communication.

The ideas presented in this paper are based on experience in both teaching mathematics and computer science at the college level and telling stories professionally. Over time, it has became apparent that education, specifically the lecture format of content delivery, has more in common with storytelling than it does with acting, or the recitation of memorized facts. Consequently, an exploration was initiated of what others had written on the subject (Dear, 1991; Egan, 1986). In addition, this author found his own lectures beginning to resemble stories, due in no small part to his being a professional storyteller. Therefore, this paper represents

both a summary of findings to date, as well as musings on being a teacher and a storyteller.

THE STORY FORMAT

Not Just The Facts!

One of the oldest formats of communication known to humans is the story format. Stories have long been used to convey information in a manner that cannot be accomplished through mere recitation of memorized facts and figures.

> Story is information coded in such a way that everyone can make use of it. Without Story, information is nothing but a lot of bricks lying about waiting for someone to make constructive use of them.
>
> (Chambers, 1983, p. 340)

Instead of focussing on the facts and figures of a given lesson, by shaping a lesson as a story students can be presented with the material as a cohesive whole. The information content is woven into the story, beginning with an introduction, setting up some conflict, achieving a resolution of this conflict and finally reflecting on the "lesson learned" by the story.

Introduction & Conflict

In an assessment driven model of teaching, learning objectives are generally presented to students at the beginning of a lesson, with the assumption that the end of the lesson meets them. These objectives are framed with respect to what the student will be able to do, under what conditions, how often, and with what degree of success. Learning objectives most often focus on one or more of the

cognitive levels presented in Bloom's Taxonomy (Bloom, 1956).

Story introductions also set up expectations, as do objectives, but not by listing measurable goals. Rather, a story introduction introduces the characters and setting for a story to the listener and conveys the main thrust of the story being told. This is not to say that objectives need to be eliminated altogether.

Egan (1986) approached the crafting of lessons as stories as an alternative to the learning objective approach. Egan stated that instead of objectives, a primary conflict is presented which is then subsequently resolved in the course of the story. Egan's research dealt primarily with the elementary grades, reducing these majors themes to simple, binary opposites.

College students, on the other hand, are quite capable of dealing with stories of greater complexity than are younger students. This is due to their exposure to a greater variety of story formats and styles. Therefore, the method presented in this paper does not attempt to augment learning objectives. Rather, it shows how story-lessons can utilize learning objectives as alternative forms of conflict.

For example, consider a lesson that centers around various sorting techniques used in computer science. An insertion sort may be a simple sorting technique, but it is inherently time-consuming because of its linearity. The Quicksort method avoids this difficulty by taking a divide-and-conquer approach to sorting.

In our "story", therefore, students will be introduced to a world where they need to sort a large data set (cast of characters), but all that is known is an insertion sort (setting), which will take too long. The objective is to be able to sort this list in a more efficient manner. The conflict is a data set too large to use an insertion sort.

Climax and Resolution

Once the introduction has been completed, the cast of characters and setting presented and conflict conveyed, the story can then be told of how a divide-and-conquer scheme such as Quicksort can "save the day". The "plot" could proceed through an analysis of why an insertion sort is time-consuming, show students how by using a technique such as Quicksort the number of comparisons required to sort the data set can be reduced, and then come to resolution by describing the Quicksort in detail.

What matters in the development of this story is not the exact style used in telling it, but the fact that conflict is an integral part of the story as opposed to an objective or goal attempting to be met. A lesson, like a story, is not a race whose goal is the finish line. On the contrary, a lesson is a tale told of how something is done, why something occurred, or what is believed to be true about a certain topic. It is over the course of telling a story, of presenting a lesson, that learning is accomplished, no matter how long it takes to get to *Happily Ever After*.

Anti-Climax (Reflection)

In the story of sorting, the learning objectives have not been eliminated. Instead, they have been re-framed as conflict, which is subsequently resolved in the story. Once this has been accomplished, it is then time to reflect on what this conflict resolution has produced. Faculty can show students how the cast of characters are in the desired order, but that the computer did not need to do as much work to obtain this result. Thus students, as programmers, have created a program that works faster and more efficiently. It would seem that everyone does live *Happily Ever After*.

Or perhaps not. Questions may be asked of the listeners, such as any good teller might do. Students might be asked if there are any conditions where an insertion sort is better than Quicksort. If so, could they test for these conditions and then choose the appropriate method for a given data set? This last aspect of story-lessons shows how lessons in a unit can be viewed as a sequence of serial tales or, as Egan proposes, as episodes in a "soap-opera".

CONCLUSIONS

Learning objectives are an important aspect of education. They help to focus attention on the reasons for presenting a given lesson and what cognitive level of learning faculty wish students to attain. Unfortunately, learning objectives can also turn lessons into races, in which the goal--the finish line--is the most important aspect of the lesson and the race itself is not as important.

By re-framing learning objectives as conflicts, and then presenting students with stories that resolve these conflicts, it is possible to re-focus attention on the learning process and various methods of learning. Stories, unlike races, better reflect process and allow the listener to utilize a much wider collection of learning modes. Students can learn via the affective as well as through the concrete. Students can see how initial conditions help to shape the resolution of a conflict, or how conflict resolutions are not always complete--often having loose ends or entertaining new questions.

The use of story-lessons is not meant to replace previous approaches to crafting a lesson. Rather, by presenting a lesson in a story format it is possible to increase a student's engagement in the lesson and show how it is the journey that's often more important and interesting than the destination. Even though disciplines such as mathematics and computer science do not appear

amenable to this approach, they can benefit from it just as well as any other field of study.

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INTEGRATING LEARNING TECHNOLOGY

INTO THE LIBERAL ARTS TRADITION

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INTRODUCTION

The commonwealth of Kentucky is in the process of reforming and redesigning its educational system. Technology has played a major role in bringing both quality and equality to every level of the state's educational system. Despite the inconclusive debate regarding the intrinsic educational merits of instructional technology, (Clark, 1983; Lookatch, 1995; Mayer, 1997; Russell, 1997) there is no doubt that technology can provide increased information and new learning opportunities to students. Union College is using multimedia technology to enhance the value of traditional liberal arts education in the poorer sections of Appalachia.

Located in Barbourville, Kentucky, Union College is an independent liberal arts institution affiliated with the United Methodist Church. Union College awards Associate, Bachelor's, and Master of Arts in Education degrees. The primary service area of the college is composed of 16 counties located in the Fifth Congressional District of Kentucky. Union College is a learning community dedicated to creating personal, intellectual and social transformation through the pursuit of knowledge, wisdom, service and spiritual growth.

One of the ways this mission is fulfilled is through service to the region's educationally under-served--women,

minorities, rurally isolated and economically disadvantaged. Union College has a broad and vigorous network of community education, outreach and service programs, in response to its location in Appalachia, and in keeping with its long-established mission to improve the quality of life in its region.

Table 1 shows the number and percent of the undergraduates who are economically disadvantaged (low income) and first generation college students, economically disadvantaged only or first generation college students only.

Table 1. Number and Percentage of Undergraduate Students Meeting Economically Disadvantaged/First Generation College Criteria

	1994		1995		1996	
	#	%	#	%	#	%
Economically Disadvantaged AND First Generation College	246	36	306	43	416	63
First Generation College ONLY	192	28	164	23	152	23
Economically Disadvantaged ONLY	82	12	79	11	73	11
TOTAL	520	76	548	77	641	97
Total Enrolled	692		712		660	

High schools in the College's primary service area are meager; therefore, their graduates are academically under-prepared as they enter college. This fact, along with the demographic conditions exhibited in the College's primary service area, results in many students coming to Union College lacking the experience of technological and cultural opportunities available to other students in the nation. They often demonstrate a lack of adequate academic preparation for college and direction or focus in their studies. This creates an urgent need for developmental advising, tutoring, and personal and career counseling.

Union College has redesigned its academic program with technology, to provide its students with the opportunity to broaden their knowledge of their own and other cultures and to obtain the intellectual skills necessary for a career. The undergraduate Liberal Education Core, including the fields of humanities, natural sciences and social sciences, promotes breadth of learning and serves as the foundation for the pursuit of individual majors.

TECHNOLOGY MINI-GRANTS

Part of a currently funded Title III grant at Union College is "Improving Academic Programs and Student Learning Through Integrating Technology." The grant provides faculty with training, support, and incentives to enhance their skills, knowledge and technological understanding to enable the effective use of technology in the learning process. The grant provides monies for up to five mini-grants each academic year.

The purpose of the mini-grants is to provide faculty members the opportunity to redesign a current or design a new course which integrates technology in order to improve student learning. The grant provides a $1,000 stipend per faculty member and up to $3,000 per grant to purchase equipment and/or software to use in improving academic programs and student learning with technology.

The minimum mini-grant guidelines/requirements are:

1. Establish baseline data in order to evaluate the newly designed course. This includes, but is not limited to, grades from previous semesters for the same course and student class evaluations.

2. Establish student learning outcome statements--pilot the course.

3. Collect data at end of course concerning student learning and student opinion.

4. Present findings to faculty through demonstration at Teaching, Learning & Technology (TLT) Roundtable program meetings held on campus.

The TLT program mission is to motivate the faculty to improve with technology, while helping them cope with continual change. Two examples of projects which have been funded by the mini-grants, are a class in anatomy and histology and a course in art history. Both classes utilize visual material and multimedia software has been used to increase the effectiveness of the visual presentations.

Anatomy and Histology

The anatomy and histology class uses ADAM. interactive software to illustrate the lecture portion of the course. The software constitutes a large database of anatomical images based in large measure on the National Library of Medicine's Visible Human Project. The images are interactive and can be manipulated, so it is possible for students to perform a virtual dissection of the human body layer by layer.

It is possible to pre-select any subset of images, write text to accompany each image and organize the images, with text, into a picture book. The picture book remains interactive and the books can be sent to and retrieved from the ADAM software Web site. All picture books sent to the Web site are available to all other users of the software, thus creating a collaborative learning

environment on-line. Previously, students had dissected cats in order to gain mastery of mammalian anatomy, which might then be extrapolated to humans.

The ADAM software has provided a better learning environment in two aspects:

1. The software involves human anatomy rather than cat anatomy. This has made human anatomy more transparent to the novice students who had difficulty with cross species extrapolation.

2. Undergraduates rarely achieved the dissection skill level required to preserve anatomical structures. All students achieve the "virtual dissection" skill level required to preserve anatomical structures in the ADAM software.

The expense of purchasing and safely disposing of animal carcasses for the introductory anatomy course is also avoided. Instructors have the option of performing expert dissections which can be video taped and shown to classes as a supplement to the software.

Art History

The art history course uses networked computer software (i.e. Netscape or Internet Explorer) and presentation technology (i.e. Astound or PowerPoint) to increase the variety and number of art images available to students. The objectives of the art history course are:

1. Describe and identify particular style characteristics relating to different periods and styles of art.

2. Identify influential artists and their works from various historical periods.

3. Discuss the social, political, and religious influences on art and artists throughout history.

The inclusion of technology has enabled students to observe a broader range of artworks and thus deepen their understanding and appreciation of art and its significance throughout history. The new programs have provided students with a variety of visual presentations of art (both video and pictorial) and offered a more stimulating presentation of materials.

Given the large quantity of material available on the Internet students can view art treasures from Angkor Wat or Aboriginal Australian rock paintings. This broadens the focus of art history beyond the classical works of The Ming Dynasty or Renaissance Europe.

While the technology has not replaced the need for textbook material, it has provided opportunities to view and discuss many more examples of art and obtain the opinion of many art experts via Internet publications. Each student also has the capability to review materials more completely, catch-up on materials missed due to class absences or individually explore an area of particular interest.

CONCLUSIONS

For over a decade a debate has continued regarding the effect of media on learning or motivation. Starting with Richard Clark's analogy that media are "mere vehicles that deliver instruction" (1983, p.455) to Mayer's plea to change media effects research to a "knowledge construction metaphor" (1997, p.7), no clear consensus has been

reached. The sheer volume of decades of inconclusive research (Russell, 1997) and the problematic nature of media research (Lookatch, 1995) makes reaching any rapid conclusion unlikely. Because of this uncertainty, the approach to instructional media at Union College has been to use media to provide instruction that would be cumbersome or cost prohibitive to provide via traditional means.

Although Central Appalachia is Union's primary service area, the College intentionally recruits students from numerous states and foreign countries who enrich and diversify the College community. E-mail and on-line video programs have also made contact with students and experts in other parts of the world a reality even in rural areas of Appalachia. It is common to see a Brazilian student sitting in the Union College library and speaking to another student in Sao Paulo via Internet telephone or typing away in a conversation in a Portuguese language "chat room".

For students in rural areas or poor urban communities, the choice is not between the Internet and a trip to the art museum but rather it is a choice between the Internet and nothing. Although not reality, mediated experiences frequently provide the only learning available. Cost has always been a factor in educational media but with advances in manufacturing techniques and digital storage capabilities the price of 'at least' adequate media is coming within the reach of all schools.

Technology at Union College has increased student/teacher interaction and stimulated critical thinking and classroom discussion. Combining technology with traditional liberal arts teaching methods such as guided reading, Socratic dialogue and case studies has enriched the educational experience of Union's students.

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THE EFFECTS OF GENDER

AND ACADEMIC PROGRAM

ON LEARNING STYLES AND ATTITUDES

OF UNDERGRADUATE STUDENTS

USING MULTIMEDIA, WEB-BASED

ANATOMY LABS

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The proliferation of Web-based courses in distributed learning has the potential to revolutionize today's teaching--especially if these methods address the preferred learning modalities of the students. By integrating technology into the classroom, instructors are being given new tools with which to present material in an interesting and productive manner.

There is good evidence that computer-facilitated learning has advantages above and beyond traditional learning methods in that it provides new options previously unavailable in traditional classroom instruction (*Rezaei & Katz, in press*). Combining computer-based learning with traditional classroom laboratory and textbook instruction offers students a valuable resource that can also be cost effective and time efficient (*Rezaei & Katz, in press*). Furthermore, it would appear that students are generally eager to work with computers (Cotz, 1998). However,

Anderson and Jeary (1998) reported that although the Web was perceived by other university students and instructors as a valid educational instrument, significant barriers to adoption of the technology were noted. These included access restriction (e.g., inability to connect from home) and concerns about the relative effectiveness of the technology (i.e., is it worth the time and expense?).

Cote (1998) looked at the relative advantage of computer use over traditional methods (i.e., text and microscope) at a university level, in studying histology slides. He found that the majority of respondents saw computerized histology slides as an advantageous adjunct to their traditional study methods. The respondents saw observable benefits to the Internet and agreed that they would like to see this technology used more extensively to support learning.

Computer-use has been found to improve students' understanding of material. For example, Hacker and Sova (1998) found, for university students, a 15% higher achievement gain for computer-mediated delivery when compared to traditional delivery methods.

In order to maximize student performance, computer-based resources should be designed to fit the cognitive style of the learner. Using the Keith (1978) Learning Style Inventory, Seitz and Robey (1995) found that university students who were categorized as abstract thinkers performed better on abstract computer models, whereas students who preferred active experimentation performed better on analogy-based computer models.

Gender differences are well documented and are relevant especially if the issues are performance related (e.g., willingness to work with technology). Busch (1995) found that women reported less access to and experience with technology, but there were no differences between men and women undergraduate business administration students in attitudes toward computers. However,

Lundeberg, Fox, and Punochar (1994) found that men tended to be more overconfident about their knowledge of a topic under conditions in which their knowledge was actually incorrect.

The purpose of this study was to examine the gender and academic program relationship to attitudes and learning styles of undergraduate students.

DESCRIPTION OF THE STUDY

At the University of Calgary, an interactive, multimedia, Web-based computer lab was incorporated into the fall semester Anatomy curriculum designed for first-year Kinesiology students. Locally developed Functional Anatomy software was integrated with a commercially developed dissection program and other online resources.

The labs were designed from the perspective of creating a resource fundamentally different from traditional lectures and labs. The program has four components that were designed to compliment the traditional lab and lecture aspects of the course. Placed on the Web, the program was accessible through the Kinesiology multimedia computer facility and from any external location with high speed Internet access. Entrance to the program required a password and student identification.

One hundred and ninety students of the 233 registered in the course agreed to participate in the study (81.5%). There were 67 males and 123 females with a median age of 20 and an age range of 17 to 41. Forty-four percent of participants were first-year students and 33% were second-year students. Kinesiology students comprised 51% of the volunteers and science students comprised 16.4%. Over 85% of students indicated that the course was required and 29% took the course because it was a "career path". Only 5.3% of students took the course out of general interest.

All students were provided with four scheduled computer lab times and additional open lab times were available. Students who volunteered completed an online entry survey and Learning Styles Inventory (Felder, 1993). Once students completed all four components of the program over the course of the fall semester they had the option of completing an online exit survey. The exit survey addressed the students' reaction to the various aspects of the program as well as their perception of computer skills and knowledge obtained over the semester.

The present study provides the preliminary results of the entry survey, examining gender and academic program groups on measures of perceived usefulness of computers, course confidence and content and learning styles--i.e., details versus overall structure, pictures versus words, doing versus thinking, and facts versus ideas (Felder, 1993).

FINDINGS

When the four learning styles identified by Felder (1993) were studied, it was found that overall, students demonstrated a strong preference for visual learning (i.e., pictures versus words). In a comparison of learning styles with 'comfort in working with computer technology' (i.e., general computer use, Web, software applications), students who preferred detail to overall structure were more 'at ease with computers.' There was also a tendency for visual learners to be more at ease with computers.

An assessment of gender and academic program showed that there was no difference in motivation to do well or in the perceived amount of time required. While over 70% of students agreed or strongly agreed with the statement "I feel comfortable using computers," women were significantly less comfortable than men. However,

there was a tendency for women to see the computer as more useful.

Over 80% of students agreed or strongly agreed with the comment that they "had confidence they would do well in the course", yet men were significantly more confident than women. Also, there was a tendency for Kinesiology students to have a higher degree of confidence than other students.

CONCLUSIONS

These results represent a preliminary analysis of the data. The students in the study have just completed the exit survey and it will shortly be possible to compare entrance and exit data as well as overall performance variables. Based on feedback, modifications will be made to the computer program in time for the fall semester of 1998. At that time, the study will be replicated to determine if the observed differences can be generalized or if they are sample specific.

Clearly, there are gender issues with technology which need to be considered when designing programs. Overall, however, students appear to be accepting of the introduction of technology into university courses. Visual learners, and those who prefer detail, also appear to be more comfortable with computers. These findings support the use of technology to facilitate the learning of anatomy, which is highly visual and detailed.

Numerous faculties are collaborating on this project and so the multimedia components of the lab (e.g., video clips, surface anatomy and joint movement) have been designed to fit into a database structure which is accessible to the other researchers and instructors. For example, the Faculty of Medicine at the University of Calgary has adopted a problem-based learning model (Mandin, Jones, Woloschuk, & Harasym, 1997; Pramkumar & Rambor,

1996) that requires students to access the material to help problem-solve specific cases. As the database evolves, it is hoped that it is flexible and easily accessible. The underlying philosophy of the instructors and designers is to develop resources that emphasize wellness, an informed consumer, performance enhancement and life-long learning.

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TEACHING WITHIN THE DILEMMA--

SCIENCE TECHNOLOGY AND

SMALL COLLEGE CONSORTIA

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INTRODUCTION

Technology for the scientist moves well ahead of funds available to support such usage at most small schools. Scientists who balance effective, proficient teaching with the current needs of their scientific disciplines are faced with the challenge of integrating the continually advancing discipline-specific technologies. If small schools are to continue to be effective in both attracting students and training scientists, their faculties must find creative ways to compete and locate funding to advance their technology needs and integrate these within the small college's technology support structure.

Funding and resources have typically shifted most training for science technology to large universities. However, small schools' professor/student ratios provide creative teaching models that can far exceed training opportunities for undergraduates at larger institutions. To attract and retain faculty and to maintain high caliber instruction at small institutions, however, professional growth opportunities along with the availability of appropriate support technologies are necessary.

This presents a dilemma with multiple components. Can small colleges retain science programs that have current application opportunities for their students if funding requirements are so great and the retention of

faculty is so difficult? Do students have to sacrifice availability to technology advances in order to have interactive opportunities of working with faculty?

Consortia provide a unique potential for addressing some of these concerns. A novel consortium experiment has begun in the Appalachian Mountains of North Carolina, enabling these schools to initiate a response to some of the above concerns. This consortium, The Consortium for Environmental Curriculum Development and Research (Lassiter, 1998), has had some encouraging developments. Presentation of the model on which the consortium is based may provide insights for addressing the problems enumerated above.

Scientific Technology Needs Are Broad Based And Sophisticated

Scientific technology is often sophisticated and very expensive, requiring much assisted training. This is the reason that many of the doctoral instrumentation technology programs are housed at large universities where resources are available for the required capital, support staff and faculty. Thus, these resources enable the collaboration of numerous scientists in joint training and utilization of instrumentation technology while also providing a natural exchange of ideas that prompt new developments in investigation and technology.

The professional training of scientists at large universities includes encouragement to utilize numerous technological mechanisms. Thus, many scientists coming to teach at small schools are able to bring this unique training in technology and the collaborative exchange of development ideas to their teaching.

Scientists Of Small Schools Are Faced With A Dilemma

Often, scientists that are attracted to small schools will leave due to the inability to grow professionally within their fields. Scientists wishing to advance professionally at a small school can publish within fields that do not require instrumentation technology or direct their growth toward education or administration within arenas that do not require advanced scientific technologies.

The ramification of the above shift is illustrated when small schools fail to offer contemporary science programs and students fail to gain the instrumentation technology skills that larger universities can offer. However, scientists at small schools are aware of the potential that their setting holds and can be supported by instrumentation to develop their programs. The major task is overcoming typical barriers that have prevented development in the past and to recruit faculty that can bring current technology to these schools.

It is also necessary to provide incentives within these programs. In order to implement instructional strategies that address instrumentation technology needs, faculty must be encouraged to create the environment and technology base that will adequately address this dilemma.

Critical Concerns

The scientist or group of faculty at small schools primarily engaged in teaching must find avenues that address the following concerns:

1. Faculty must be committed to integrating teaching into their own professional growth and thus bring the full benefit of this process to their students.

2. Professional development opportunities and exchange between scientists must be made available to prompt developments in both academic programs and professional pursuits. Avenues must be developed to bring monies to the school for technology acquisition that can support the contemporary training skills and research for their science program.

3. Faculty must communicate the unique requirements of the program development and advancement needs to the administration of their institution.

4. Opportunities must be created that will provide time for scholarship and development of the instrumentation technologies specific to the science program.

Typical Support For Technology And Professional Development

As small schools strategically position themselves to respond to critical technology needs, it is understandable that these pursuits primarily support the typical needs of the entire campus. Technology that meets the needs of all disciplines is the first to be addressed and thus takes the form of communication, classroom technology and student independent interactions. This bypasses the need for technology in the laboratory and within typical science

programs. Scientists are comfortable with technology and rapidly master technology supported on small campuses. They can become key technology facilitators on their campuses, but this directs their energies away from the need to develop their discipline-specific technology.

Furthermore, faculty development funds could support discipline specific technology needs, but typical support involves conference attendance and scholarship linked with larger institutions. Though these types of support are often very helpful, the instrumentation opportunities that may have been made available to the scientist through these development opportunities have not advanced the avenues of teaching at the institution of residence, due to lack of adequate technology equipment.

Scientists will need to be able to enhance the technology at their institutions in order to advance their program and teaching. Since typical opportunities for professional development do not enable the scientist to address the necessary components that advance the needs of instrumentation technology, new mechanisms must be initiated.

THE CONSORTIUM MODEL

Consortia can address many of the limitations to professional development and scientific instrumentation technology at small colleges. Colleges that work together can jointly pursue funds while providing the environment that prompts professional development. The consortium also provides the support and technological training and assistance that is often absent. Involving colleges in the same general area can be extremely advantageous since they can meet often and easily integrate their teaching and direct assistance.

Consortia colleges will do well to combine their advancement and grant writing efforts since the consortium

can more adequately serve the collaborative needs of the science programs than any single college. A consortium can creatively allow a collaborative body of scientists to develop and integrate their respective programs, their professional development and the active integration of their students.

Key Strategies

The following summarizes some key strategies for a consortium:

1. *The consortium addresses the challenges of scientific technology and professional growth at a small college.* The meeting together of consortium faculty members can prompt the development of joint teaching programs and cultivate a complement of specific skills. Such meetings enhance the interchange of colleagues from the same school and between the participating schools. These scientists can jointly launch projects that stimulate professional growth. The projects can be easily linked with projects on their campus or in their courses, thus providing an effective avenue for student involvement.

2. *The consortium can improve funding for the acquisition and support of advanced technologies and professional exchange.* A consortium can jointly develop grants to address scientific interests and research. This collaborative pursuit of funds encourages ongoing joint professional development. The collaboration provides an

environment similar to a large university where ideas can prompt novel investigations and collaboration of teaching faculty can link these grants with the unique teaching components of each academic program. As an added benefit, this pool of collaborators becomes a team of trainers, thus launching an extremely valuable component of collaborative grant ventures--joint training that simultaneously strengthens multiple colleges.

3. *The consortium enables the communication of development and advancement requirements to college administration.* The formation of a consortium enables faculty to approach their development personnel with projects that communicate their interests and needs. Additionally, the team of colleagues serve as assistance personnel in preparation of grants and can assist their campus personnel who also face the problem of limited resources. These grant proposals communicate the work and pursuits of the consortium to the administration.

4. *The consortium can create avenues for scholarship and the development of technologies.* As the consortium becomes successful in pursing monies for its joint projects, these participants can create opportunities that provide professional recognition for their scholarship. They even have at hand, assistance from people who have jointly shared in various professional development projects. The development and

> expansion of their program into the utilization of new technologies can be made possible by this collaboration. Teams of faculty can now have the resources and support to venture together into research projects and even into joint publication in a fashion approximating the interchange at large universities.

A word of caution concerning joint grant proposal developments. While it is tempting to develop grants that share instrumentation, it is generally more beneficial for each school to pursue acquisition of technology for residence on its own campus. As different campuses utilize their own instruments, joint training and support of the common instrumentation can be made available.

CONSORTIUM FOR ENVIRONMENTAL CURRICULUM DEVELOPMENT AND RESEARCH

North Carolina colleges of the Appalachian Colleges Association have initiated the Consortium for Environmental Curriculum Development and Research under the directorship of Montreat College. Many of the objectives, pursuits, and developments presented above come from the activities of this consortium. It attempts to support the development of the schools concerned. Much is still awaiting development, but the consortium meets monthly to support the exchange of ideas, advise each other on campus program developments, provide peer training in instrumentation and instructional software, pursue funding for collaborative efforts, coordinate instrumentation donation programs, and jointly develop laboratory exercises.

The consortium has received monies for grant and project development. It has proposed grants for the

development of concurrent Web laboratory interface projects and joint software development. It has received monies for grant and project development. It is currently launching efforts for joint training and development of a modular instrumentation curriculum. The successes and directives of this consortium have enabled collaborative advancements that suggest and substantiate the potential of this model as a means to address some components of the instrumentation technology dilemma of small schools.

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BEYOND CONSTRUCTIVISM

IN THE LIFE SCIENCES

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INTRODUCTION

Students often fail to understand concepts in the sciences despite the best efforts of good university teachers (Pearsall, 1997). It has been recognized that there are difficulties experienced in understanding and teaching scientific concepts and that these difficulties are widespread. They affect students over a wide range of abilities. These difficulties have, however, been identified as a normal part of the learning process (Mintzes, et. al.,1989; Wandersee, et. al., 1994).

Learning difficulties arise as students attempt to construct meaning around new concepts based on their previous domain specific knowledge. This is the premise of the constructionists' theory of education (Novak, 1993). The teaching of knowledge, skills, attitudes and values within a student body, however, is not completely solved by knowing and applying constructionist education. Although construction theory provides a framework on which to build teaching skills (Matthews, 1998), the outcome of teaching and learning must go beyond constructivism.

This paper examines the knowledge gained from both developmental psychology and educational research in the life sciences during the last twenty-five years and highlights the understanding of how faculty teach and students learn.

THEORETICAL UNDERPINNINGS

Constructivism and its Limitations

The human constructivist perspective was first described by Novak as "the unity of psychological and epistemological meaning making" (Novak, 1993, p. 167). It is linked closely to Aushubel's (Aushubel, et. al., 1978) cognitive assimilation theory. Aushubel's work builds on that of Jean Piaget (Sandstromm, 1966), whose work formed the basis of developmental psychology in relation to thought and language. Piaget's preoperative, operative, concrete and formal thinking phases of development fitted well within the realms of understanding child development in the elementary and high school .

Unfortunately, there are many in our society who have difficulty with formal thinking and they carry this legacy with them for a long period throughout their lives. Among them are the illiterate, the economically disadvantaged and psychologically disturbed. They are not typical of the average university student as they usually do not progress to higher education.

The skill in tailoring educational experiences (i.e., teaching) is not confined to the high school where the mark of a good teacher is their vibrancy and versatility of method. Usually it is the students who are more able to think formally that benefit from the good teaching (and survive some bad teaching) who go on to colleges and universities.

The finesse in teaching skill at the higher education level, where it is necessary to account for the differences observed in students' ability to think formally, is related to the teacher's ability to account for individual differences and talents among the students. It is therefore necessary to go beyond constructivism in science education because, as a theory of learning, it offers no guidance on adjudication

between other theories (for example, behaviorism and developmental) or styles of learning, the organization and sequencing of content--and finally, it rejects the value of pedagogy and the training of teachers in a variety of skills. (Osbourne, 1996).

In science, knowledge is incomplete, curtailed, and limited, but it grows through the creative efforts of individuals who are continually asking questions by forming hypotheses and testing their ideas experimentally. Their effectiveness in passing on this knowledge to their students will depend on their ability to teach, not their ability to do research. Research in the sciences will identify the subject matter while the teacher's skill will deliver the content.

A Holistic View Of Life Science Education

To make good use of the constructivist approach, higher education faculty might also make use of Howard Gardner's (1987) multiple intelligence theory in order to be able to present content in such a way that many avenues to meaningful learning are presented to the student. Gardner's premise is that the student has a capacity to learn and an ability to assimilate this learning from seven basic intellects, common to all, but developed to various degrees within the individual. Gardner admits to being Piagetian, and at one time argued favorably for a unitary view of intellect (Gardner, 1987). However, his multiple intelligence theory gelled when he was able to consider the variations he observed in the multiple talents of people from different cultural backgrounds. Hence, a good teacher will get to know their students and use ideas and models which can address students' unique intellectual capacity based on their cultural background.

MEANINGFUL LEARNING

For meaningful learning to take place at least three criteria must be met:

1. *The material presented to the student must have potential meaning.* It is the role of the teacher to be aware of the knowledge base of students and to provide them with concepts which fit within their existing knowledge constructs and capacity to learn. It also needs to be culturally relevant. This in part explains the difficulty observed in aborginal education, but it is not limited to that culture. Asian students also have difficulty, particularly in the nursing program at the author's institution, due to cultural differences and different language framework.

2. *The student must possess a framework of relevant, domain specific concepts to anchor this new knowledge within that existing framework.* This is usually the response of those who set the overall program. It normally exists in the form of required prerequisites. However, as of 1998, the University of Newcastle has taken an 'assumed knowledge' position with respect to prerequisites. This has put the onus back on the student to accept the responsibility for their own learning program. Such self-empowerment can be a good thing providing students are aware of what they actually know. Simply replacing the words 'assumed knowledge' in front of the subjects which

were prerequisites, is a lazy opinion on behalf of the teacher, particularly in view of the growing importance of competency-based assessment. Most faculty would, in the interest of the student, provide a list of principles and concepts which they would expect students to have prior knowledge of in order to succeed in the program of study.

3. *The student must choose to voluntarily incorporate new concepts in a non arbitrary, non verbatim fashion.* In other words, they have to be willing students. When these criteria are present, then the inclusion of new ideas into long term memory is improved and the potential for insight is increased. If new knowledge fits into the existing knowledge constructs through a variety of facets, then meaningful learning occurs. The principle benefits of meaningful learning are enhanced retention and retrieval of new knowledge.

Therefore, it is important for the teacher to know their students. A willing and interested student is always an asset both to themselves and the teacher.

INCOROPORATING NEW KNOWLEDGE IN THE LIFE SCIENCES

If the above three criteria are met four processes occur within each student to account for meaningful learning (Aushubel., et. al., 1978). These are:

1. *Subsumption.* In subsumption, new, specific knowledge is incorporated into the more general concepts held by students.

2. *Superordinate Learning.* In superordinate learning there is conceptual restructuring to accommodate new knowledge.

3. *Progressive Differentiation.* In progressive differentiation, concepts are clarified and arranged in neural concept maps. Parallel research, more recently in science education, has highlighted the use of the concept map development as a valuable tool in illustrating how the knowledge is progressing (Wilson & Williams, 1996).

4. *Integrative Reconciliation.* In integrative reconciliation, closely related concepts are explicitly delineated within the neural concept map, making knowledge more interconnected, integrated and cohesive.

It is within the constructivist perspective that short circuits have been identified. Wilson and Williams (1996) noted difficulties with the progress of student teachers saying that some misconceptions, or 'noise', remained stubbornly resistant to change. Such misconceptions have also been identified in trained and practicing nurses (Wilkes & Batts, 1996). Also, not surprisingly, misconceptions in how students learn and the knowledge of effective teaching have also been identified in college science professors who have achieved their position primarily through research. (Fedock, et al., 1996).

It is in the identification and treatment of short circuits that the role of the teacher is paramount. There are

many concepts which must be built upon to take a child from primary school to graduate school. Throughout this growth students are exposed to many misconceptions. These misconceptions can creep into the students' knowledge banks and cause 'noise', thus preventing adequate assimilation of knowledge.

An illustration of the above is the conflict caused by a student resolving the creationist approach to life against that of evolution and the need to understand and practice techniques in genetic engineering. In this instance, some students will never make it because of the noise generated by their belief systems.

A WAY FORWARD

An important finding, which relates to what happens early in a teaching program, became apparent in the longitudinal study on conceptual change in the life sciences (Pearsall, et. al., 1997). It is one most well trained teachers are aware of, but few become proficient at mastering. The finding is that there is a strong correlation between students' interest and ability to learn new work. There is always a high degree of student interest at the beginning of a new program of study, but the average student's interest wanes throughout the program for a variety of reasons. A teacher's skill is related to the ability to maintain this interest and to build on that which is naturally present at the beginning of the program of study.

Key Issues In Science Education

In a review of research in undergraduate science education by Peter Laws (1996), which spans the last twenty years (during which there have been major developments in educational psychology and learning

theory), seven key, inter-related issues were identified. They are briefly summarized below:

1. The increasing diversity of the undergraduate body in terms of attitudes, values, and experience must have a profound effect on the kind of science education offered.

2. The specific challenge is to better characterize aims and values to identify the purpose of the different components (e.g., lectures, labs, tutorials, etc.) and the curriculum.

3. There is a sharp distinction between the theorizing of researchers and the practice of teachers themselves. The nature of this gap needs further research.

4. The structure of teaching in the disciplines may be too dependent on the ontological and epistemological aspects of the subjects themselves.

5. The planning of teaching experiences needs to take into account students' conceptions and learning processes.

6. There is considerable evidence to suggest that university science teachers are conservative in their practice and reluctant to adapt it.

7. The relationship between the status of science teaching and research in

contemporary universities is likely to be a key factor affecting teachers' attitudes to their work--and this relationship has many dimensions.

These findings are relevant to the teaching of life sciences at the higher education level. By emphasizing its success and ignoring its weaknesses, constructivism has acquired the image of an all embracing theory when at best it can only be considered a partial contribution to the real events which take place in the learning environment.

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INTENTIONAL AND INCIDENTAL LEARNING

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INTRODUCTION

This discussion of the processing of knowledge is based on the cognitive approach to learning (Ausubel, 1968; Bartlett, 1967; Bransford, 1979; Gagné, 1977; Smith 1978), and more specifically, by the schema theory of knowledge acquisition (Carrell & Eisterhold 1983; Omaggio, 1986; Schank & Abelson, 1977). Intentional learning results from students' individual efforts in or outside the classroom environment. Incidental learning occurs when students are exposed to material under study and directed to process it within a meaningful framework. The results of this research have led to some conclusions about how to make the learning process more efficient for the acquisition and retention of knowledge.

ACQUISITION OF KNOWLEDGE

According to the cognitive approach, content-based knowledge is acquired and retained by processing information from short-term to long-term memory. After sensory input is received and attended to, short-term memory will hold about 7 items or "chunks" of information at a time which can be retained only as long as they are being rehearsed. (Many sources cite looking up a phone number before dialing as an example of this temporary short-term retention.) Once attention is diverted to subsequent sensory perceptions, these items are lost and cannot be retrieved because they were never stored.

Long-term memory is seen as limitless, but committing something to long-term memory is slow. It requires rehearsal to encode information and store it in long-term memory in a meaningful or conceptual mode. Unlike short-term memory, however, once an item is committed to long-term memory, it has a long retention period.

The retrieval process which verifies the information as having been learned depends on the use of cues to match or link the information in the search process. Through these links the information is retrieved into short-term "working" or "conscious" memory where it is readily accessible. The key is to be able to retrieve this information, because forgetting is merely the ineffectiveness of the search and retrieval processes, i.e., forgetting is due to interference from previous or subsequent memories (proactive or retroactive interference).

In other words, for any learning to be effective, the student must be open to the learning process. S/he must then pay attention to the concepts and details under study, accessing prior knowledge stored in memory to generate connections to the new information to be processed or encoded so that it may be retrieved at a later time.

Learning is facilitated if the process is organized in accordance with a deep, meaningful or "semantic" structure. This requires active involvement on the part of the learner, after which internal or external feedback verifies or fine-tunes by correcting mistaken assumptions (Svinicki & Meyer, 1996).

Successful independent learners use finely developed study skills and strategies to process information on their own. These are the students that instructors can be confident will take their lessons home and learn them on their own through rote rehearsal, mnemonics, practice and application. However, not all students succeed through such "intentional" learning. Knowing how information is

processed, however, will allow the instructor to guide students to apprehend content "incidentally."

SCHEMA THEORY

Cognition researchers agree that no learning is effective without prior knowledge. The new information is related to this prior knowledge when processing it into long-term memory. According to the "schema" theory of memory, a text (written or spoken material) has no meaning in isolation. Instead, the text provides a direction for students to construct meaning from their own cognitive structure (background knowledge) which is accessed during the comprehension process. These cognitive structures or "schemata," (also called "scripts," "frames," and other terms by different theorists) are internal representations for a given message containing elements not entirely derived from the words themselves.

Learning involves a process of fitting meaning into existing schemata--and the individual's own personal background and interests constantly influence this input. It is assumed that schemata are organized hierarchically but this knowledge is fluid, not static--it is in a continual process of reorganization, as the individual comprehends new messages. If a person has no schemata (prior knowledge) to activate as a guide for interpreting the message, s/he will either fail to make hypotheses about the incoming message and not comprehend it or will activate the wrong schema and misinterpret the message. For these reasons, an individual cannot learn without contextual background knowledge already in existence, or without first building the appropriate contextual knowledge.

IMPLICATIONS FOR INSTRUCTION

Contextualization is of primary importance to the learning process. Memory is reconstructive, influenced by inferences and interpretations made during acquisition, and this results in distortion in recall. Therefore, contextualizing is important to facilitate learning because it makes information more meaningful as well as activating the appropriate "schemata" to which an individual incorporates new information. As an example, a visual cue might help prepare students to better understand a listening comprehension exercise by activating appropriate background information. Overall, input is interpreted differently because it involves contributions from the learner's prior experience--the more exposure to appropriate context, the more accurate the interpretation.

From contextualizing, we move to decontextualizing in an attempt to facilitate transfer of learning, thus building critical thinking and problem solving skills in students. Because remembering depends on the overlap between new information encoded at acquisition and the information available in the retrieval environment, the more overlap between the two that an instructor or student can provide will enhance the transferal of learned concepts to new situations.

The above indicates that it is beneficial to attempt to apply these learned concepts in a wider variety of contexts, thus "decontextualizing" the knowledge so it can be used to solve new problems. This is the premise behind "guided" or "discovery" learning. This method proposes that forcing students to be creative and to generate their own mnemonic devices, learning strategies and retrieval cues yields superior results as compared to prompting them, because

they not only process the new information but also develop skills for effectively utilizing prior knowledge.

STRATEGIES TO FACILITATE RETENTION

Because not every student engages successfully in intentional learning by processing information in efficient ways in order to be retrieved and applied critically, instructors may develop methods to aid in incidental learning. The following lists a series of strategies that an instructor may utilize to help guide students in acquiring and developing mastery over course content:

- Processing information is influenced by prior knowledge already in the memory of the individual; "paying attention" is actively combining background knowledge with new information. The implication for instruction would be to make material meaningful to the student by relating it to prior knowledge. Make use of what students already know to serve as a basis for learning or provide them with the necessary background knowledge before presenting new topics. It may be necessary to develop prerequisite subordinate skills first so that these may be recoded as functions of new skills.

- "Prime" the students to activate appropriate concepts for more accurate understanding by contextualizing. Instructors may aid students in activating contextualized background knowledge for better understanding and processing by including pre-reading and pre-listening activities. Examples would include giving titles, introductory statements, pictorial cues or advance organizers and having students make predictions about content before the target exercise. The use of "advance

organizers" before a comprehension activity--for example, providing a visual cue--will supply the students with a framework or a logical context through which they may make sense of the material to be assimilated.

- Vary the presentation of information because the more similar the material in sequential tasks, the more interference in retention. A dual-processing model of encoding exposes students to verbal and image input. Integrating a variety of presentation media is beneficial due to different learners' styles, but it also helps the processing of information if the same message is reinforced by different sensory modes.

- Enhance retention and learning transfer by organizing materials to be "attended to" into categories and into tables, graphs and diagrams as extra cues. Also point out organizational patterns and categories, illustrate concepts with examples, provide instructional objectives and suggest relevant questions that will enable students to evaluate their own mastery.

- Personalize instruction. Schema theory postulates that activating a reader's prior knowledge about vicarious or real experiences related to instruction would improve his or her comprehension and recall. Enhance this by choosing content material that relates to learners' own experiences.

- Vary the features of the learning tasks and vary the contexts used to illustrate concepts to facilitate transfer of concepts to new situations.

- Provide feedback on the learner's performance--testing is a reinforcing event. Material assimilated under conditions of aperiodic reinforcement seems to be retained more successfully than material learned under constant or regular reinforcement. Forgetting occurs more often when the material is not reinforced by later events in the students' lives--this would indicate the practicality of both relating material to be learned to real life contexts and using sporadic feedback to improve retention.

- Meaningful learning carries higher retention over time than rote memory. Therefore, one may consider reducing excessive factual material and replacing it with fewer, more significant ideas or concepts--larger abstractions "tie together" isolated and specific data.

- The conceptual units that are better organized are also more easily assimilated and stored in memory. Therefore, organizing curricula around a set of concepts and methodological principles, rather than facts, may help facilitate learning and retention.

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ACTIVITY VISUALIZATION

AND FORMATIVE ASSESSMENT

IN VIRTUAL LEARNING ENVIRONMENTS

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INTRODUCTION

Teaching, tutoring and assessing students becomes radically different in a virtual learning environment than in a traditional classroom (Harasim, Hiltz et al., 1995; Hiltz and Wellman, 1997). The more activities that are 'net-based,' the more technology-based support is required for the educator. Computers free educators to spend less time on direct instruction, but do not diminish the role of the educator. Instead, they can change the role towards guiding and helping students to put information into context. See for instance Laurillard (1993) and Ramsden (1992) for a discussion about the role of the educator. The process of guiding students is an ongoing struggle and requires thorough understanding of the learning process. For tutors and teaching assistants, virtual learning environments introduce a whole new situation.

ASYNCHRONOUS LEARNING NETWORKS

A common way to build virtual learning environments is through the use of asynchronous learning networks. Implementations of asynchronous learning networks utilize different tools for computer mediated communication. In this way, asynchronous learning

networks can be understood as an information technology infrastructure supporting educational activity. This infrastructure includes e-mail, bulletin boards and news-groups, synchronous chat systems, computer conference systems, group decision systems and more recently, the Web (Hiltz and Wellman, 1997).

The central pedagogical idea in an asynchronous learning network is collaborative learning at the time and place of the individual learner's convenience (Bourne, et. al., 1997). Such networks are best at enhancing educational activities when they serve as a way to create a feeling of a group of people learning together, and to structure and support carefully planned collaborative learning activities. The asynchronous learning network is an integration of computer mediated communication tools that in many ways are used to slow down the dynamic interaction, thus providing opportunity for reflection.

There are problems in using asynchronous learning networks. Anonymity and issues related to the fact that people do not meet face-to-face introduce initial problems with many such courses. Many students find it easy to postpone attendance when they are busy with other things. This can easily turn into falling seriously behind. It is also shown that despite good intentions when structuring a computer conference there is an extensive risk of information overload. Early and enthusiastic activity in the beginning of this type course might result in some students overloading others by posting voluminous and numerous messages.

THEMATIC MODULES

Net-based technologies such as computer mediated communication and asynchronous learning networks give educators the opportunity to structure education in new forms. Thematic Modules is a structuring philosophy

designed to overcome some of the problems outlined above (Nuldén, 1999). Central in Thematic Modules is that learning is most effective when the students are actively engaged in the process. In other words, constructivism which posits that people can only understand what they have themselves constructed (Leidner and Jarvenpaa, 1995).

Meaningful learning takes place when students can reflect on what they know and when they can communicate it to others. Therefore, in Thematic Modules, written collaboration among the learners is essential.

The basic principle of Thematic Modules is a course divided in a number of modules. Each module is a self-contained unit covering a topic presented by an expert in that field. The expert, in this case a scholar or practitioner, presents a field or topic during a two hour lecture with the purpose of creating an interest among the students. That is, the aim of the lecture is to start the week long module. The lecture ends with a more or less structured assignment depending on the lecture style of the expert. Understanding the lecture as the explicit starting point for a week long learning activity instead of a regular lecture is a twist to many of the experts and students.

The class is divided into groups of about 15 students. Each group has a Teaching Assistant who is responsible for subtly guiding the students in the asynchronous learning network when there is need for intervention, i.e., facilitating the discussion. Every module has the same basic structure: The module starts with a lecture, which introduces a topic, and ends with one or several problems that the groups are to explore further. They then work with the assignment in groups in the asynchronous learning network. Teaching Assistants play a crucial role in creating the sense of a community and collaboration among the learners as well as provide guidance in the topic of the module.

Thematic Modules have many things in common with problem based learning. For instance, in problem based learning the starting point for the learning process is a problem the learner wishes to know more about. Thematic Modules and problem based learning share the notion of teaching as initiating and managing activity, not as transmission of knowledge.

FORMATIVE ASSESSMENT AND SCAFFOLDING

The structure of a virtual learning environment with asynchronous learning networks and Thematic Modules will not in itself ensure interaction among the students and a constructivist learning process. Providing an alternative learning environment means different roles and changed responsibilities. In Thematic Modules it is the responsibility of the Teaching Assistants, and ultimately the course coordinator, to *create conditions in which understanding is possible* (Laurillard, 1993, p. 14). The most critical condition is assessment. If the assessment procedure is not congruent with educational goals the assessment can drive the learner in an antithetical direction (Swanson, et. al., 1991). The way the students are assessed will be the greatest influence on what learning strategy they adapt for the course (Ramsden, 1992).

In Thematic Modules, learning and assessment are integrated in the doing process, which is expanded to consist of the whole course. Formative assessment focuses on the learning process. Compare this to summative assessment, which is the grading of students' performance in relation to predefined goals. Formative assessment, on the other hand, is dialog and feedback.

Loss of interaction among students and educators is a serious potential risk, especially if the educators have no, or limited, feedback about the students learning processes.

Timely and individualized feedback is crucial for the learning process. This is often referred to as scaffolding which is the support provided to learners so they can participate in activities otherwise beyond their abilities.

Scaffolding provided in traditional educational settings is a well-established means of supporting learning. Instructional software, to some extent, provides individualized support by providing more advanced functionality available as the learner develops expertise.

Virtual learning environments have inherent characteristics which affect the awareness of the learning processes. The asynchronous nature of the learning activities leaves educators and students without a complete picture of the activities, progress and usage patterns. In a sense the involved persons become blind. Without a good awareness of the activity that is going on in an asynchronous learning network, i.e., activity visualization, formative assessment and scaffolding becomes un-precise and random.

EXPERIENCE AND TECHNICAL SOLUTIONS

The structuring philosophy of Thematic Modules and asynchronous learning networks were used in a two-credit points introductory course in *Informatics* for second year undergraduates at a Business School. This course was selected for partly practical reasons, mainly the number of students and the demographics.

Eighty-five students participated, equally men and woman, with an average age of 23. Five *Informatics* graduate students were engaged as Teaching Assistants for the course. Each Teaching Assistant was assigned as responsible for facilitating a group of approximately 15 students. The Assistants received a short introduction to the content of the course, the philosophy of thematic modules and what was expected of them as facilitators in the groups.

The role of the Teaching Assistants can be summarized as assisting the group in developing new insights and connecting this with previous knowledge. They were asked to facilitate the topic content discussion and knowledge development--but also to facilitate the group process and ensure active participation of all members of the group. They clearly received the instruction that they should not teach.

An activity visualization prototype with very limited functionality was designed and implemented. The activity in the asynchronous learning network was presented as plain text without visual enhancements. The functionality included automatic notifications of activity via e-mail, number of hours since every person last visited the asynchronous learning network, most recent posts by each person, most recent posts by each Teaching Assistant and a summary view of new messages.

An evaluation of the ongoing process in the course was conducted. Time was allocated for interviews with all the Teaching Assistants to discuss problems and difficulties connected to their role in the course in greater depth. The interviews were informal and focused on the questions: *What is difficult in being a Teaching Assistant in a virtual environment?* and *What kind of support would you like to get from the technology?*

It should be noted that there is a continuous dialog between the Teaching Assistants and the course coordinator, but the structured interviews were helpful to systematize their experiences. Also, one of the Teaching Assistants agreed to keep a diary for the duration of the course. The diary was then used as one source of data during a mid-course evaluation of the Teaching Assistant role.

Analyzing the interviews and the diary, a number of problems and difficulties became clear. For one, tutoring in the virtual environment was obviously more difficult than

expected according to all five Teaching Assistants. When and how to intervene in the group-discussion was perceived as problematic. Individual support was especially difficult to give because of uncertainty about individual progress. Also, in traditional tutoring activities, being a tutor is easier, because in asynchronous learning networks it is very easy to become one of the participants rather than the tutor with responsibilities.

The interviews also suggested that if the assignment presented at the lecture starting a module was structured as well defined questions, facilitating the discussion was quite different from a lecture ending with a more delicate assignment. Structured questions cause the activity in the group to focus more on answering the questions, e.g. providing solutions, rather than discussion. On the other hand, too open and free discussion topics, generate frustration in the student groups, e.g., *Is this what we should learn?*

Students and Teaching Assistants tend to have a personal discussion style which eventually causes discussions to become routinized and boring. The dynamic interaction within groups could possibly be improved if the groups were re-mixed each module. The Teaching Assistants clearly found it easier to facilitate and guide the discussion from a topic perspective than facilitating the actual process.

It is the characteristics of the virtual learning environment which bring about some of these difficulties. Fortunately the characteristics also give the possibility to design technical solutions to address the problems. Analyzing the content of the discourse can be done manually but this is tedious and boring work that is not a realistic option. Instead the computer is a perfect candidate for this task.

For instance, Xin and Fisher (1998) have used computerized analysis of usage patterns in learning

environments to evaluate and improve usability of the software. In the research presented in this paper the aim is different and the focus is on the need for continuous and updated activity awareness.

As discussed above, activity visualization is the process of systemizing online content and presenting it in user-friendly graphical format for all participants, both students and Teaching Assistants. The technical solution is a combination of different approaches and the results give individuals the opportunity to view activities, progress, and usage patterns from various perspectives. This is a possible tool to decrease the online blindness discussed above.

DISCUSSION AND FURTHER RESEARCH

This paper has discussed the need for activity visualization as support for formative assessment in virtual learning environments. This was evaluated in a course structured as Thematic Modules. The preliminary results of analyzing the limited data collected through interviews suggests that there is a need for technical support and activity visualization is a promising approach for this. The results from this study provide direction for further research on both the role of the Teaching Assistants in virtual learning environments and on the design of technology support for this role.

The activity visualization prototype is currently being enhanced to include more functionality and to present results in a visual form. Some of the future functionality will be: analysis of message lengths to reveal usage patterns and relationships; message counts in relation to time; usage patterns showing complete overview of when, where, and how to give a feel for what's happened; possibility to give individual feedback as opposed to public messages; and mood indicators to improve understanding of context.

Practice as well as research on the educator role in virtual learning environments is still in its infancy. There is a need for new methodologies with integrated supporting technology. This research has suggested one such possible integration of methodology--Thematic Modules and technology--activity visualization.

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FIELD DEPENDENCE

CONTEXTUAL LEARNING

AND ACADEMIC ACHIEVEMENT

IN ENGINEERING EDUCATION

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INTRODUCTION

This paper will present the theoretical background and an outline of a study that is now in its initial stages at North Carolina State University. The purposes of the study are to investigate cognitive style patterns among students in a lower division engineering course--traditional versus contextual approaches to teaching and learning--and related differences in the academic performance of students. The course selected for the study is required of all undergraduate students in the College of Engineering at North Carolina State University and is well-known for the rigorous nature of the curriculum.

Impetus for the study evolved from concerns among engineering faculty regarding the above factor. Since the curriculum for the course is considered by the faculty to be appropriate, they initiated a collaborative effort with colleagues in the College of Education and Psychology to investigate the extent to which variation in student achievement might be associated with variables related to

the realm of education--specifically cognitive styles and contextual learning.

Research questions posed by investigators in this study include: 1) What patterns of cognitive styles are manifest among students enrolled in the lower division engineering course? 2) How much variation in academic achievement is actually present among students enrolled in the lower division engineering course? 3) Are significant differences in academic achievement among students in the engineering course associated with differences in the cognitive styles of students? and 4) Are significant differences in academic achievement among students in the engineering course associated with traditional versus contextual approaches to teaching and learning?

THEORETICAL FRAMEWORK

Cognitive Styles

Cognitive styles have been defined as "information processing habits representing the learner's typical mode of perceiving, thinking, problem solving, and remembering" (Messick, 1970, p. 188). Cognition and cognitive styles appear to be of greatest interest in relation to educational concerns. In the authors' opinions, while motivational strategies and environmental factors may enhance learning, cognition represents the core of the learning process. Cognitive styles seem to be most relevant to variables associated with academic achievement.

Herman Witkin's field dependence model of cognitive style is considered to be one of the most well-established and widely researched models in the field (O'Brien & Wilkinson, 1992). Assessed by the Group Embedded Figures Test (Witkin, Oltman, Raskin, & Karp, 1971), among other instruments, the field dependence dimension of cognitive style is a measure of the extent to

which an individual can overcome the effects of irrelevant background elements when consciously focusing on a learning task or activity (Witkin, 1976).

> A field independent learner can easily overcome background elements and readily focus on the learning task, while a field dependent learner will have trouble overcoming the effects of background elements and experience difficulty in focusing on the learning task.
>
> (Collins, White, & O'Brien, 1992, p. 167)

Field independent learners are highly analytical in perceiving and processing information. They exhibit a tendency to organize information into manageable units and therefore increase retention of information. These individuals prefer and utilize problem-solving techniques, organization, analysis and structuring when engaged in learning situations (Witkin, Moore, Goodenough, & Cox, 1977).

Field dependent learners are more global and holistic in perception and information processing. They tend to accept information as it is presented or encountered and depend largely on memorization. They are also likely to utilize social frames of reference to determine their attitudes, feelings, and beliefs (Witkin, 1976).

In traditional educational environments, it would appear that field independent learners would be more successful when dealing with abstract and complex subjects or functioning in unstructured situations. Field dependent learners may be more successful in highly structured situations or in situations which require interaction with other individuals.

Contextual Learning

According to Bridges and Hallinger (1991), contextual or problem-based learning is any learning which begins with a problem. Gallagher, Stepien, Sher, and Workman (1995) use the term "ill-structured" to describe the complex problems associated with this type of learning. These authors describe the initial situation of such ill-structured problems as lacking sufficient information to develop a solution or perhaps to even precisely define the nature of the problem.

Cordeiro and Campbell (1996) concur with the above view and divide problem-based learning problems into "high ground" and "swampy" problems. High ground problems are of a technical nature, where a well-rehearsed procedure for solving problems is available. Gallagher, Stepien, and Rosenthal (1992) further describe such problems as having no single best way to be tackled and no single right answer. Such ill-structured problems best resemble the nature of problems encountered in the real world. A further advantage of such reality-based problems is that they tend to be more interesting, hence more motivating to students (VanTassel-Baska, Bailey, Gallagher, & Fettig, 1992). These types of problems give just sufficient information to students to arouse their interest and then motivate them to obtain more information (Snellen-Balendong, 1992).

Contextual learning problems may be authentic or simulated according to Cordeiro and Campbell (1996). Authentic problems are ones ripped from today's headlines; ones which are actual problems of current practice within a profession. Simulated problems are ones created by instructors or ones which have occurred within the profession in the past. With both types, students can feel that they are focusing on real problems which, in fact, need solutions. Boud (1985) points out that these real problems

are also inherently interdisciplinary, as real world problems do not limit themselves to one particular discipline. Therefore, another characteristic of contextual learning problems is that they will cause students to explore more than one academic area.

RESEARCH METHODOLOGY AND DATA SOURCES

The Group Embedded Figures Test will be administered to undergraduate engineering students enrolled in multiple sections of a lower division introductory engineering course. One section of the course will experience traditional classroom instructional strategies and serve as a control group for the experimental study. Two other sections of the course will be engaged in contextual or problem-based approaches to teaching and learning.

Various measures of student achievement, including final numeric grades in the course, will be collected during the semester. Basic descriptive statistics will be utilized to assess data relevant to cognitive style patterns and variation in academic achievement. Analysis of variance will be employed to explore potential significant differences in academic achievement in the course related to differences in dominant cognitive style as determined by the Group Embedded Figures Test and differences related to instructional methodology.

Cognitive style and type of instructional methodology to which students are exposed will serve as independent variables, while numeric end-of-course grade will function as the dependent variable in the analysis of variance. Interaction effects between cognitive style and instructional methodology will also be examined.

EDUCATIONAL SIGNIFICANCE

While the study is in progress, potential findings may hold great significance for engineering education in particular and professional education in general. They may suggest meaningful ways in which teaching and learning can be improved. A deeper understanding of the nature of individual differences and connections between those differences and traditional/nontraditional instructional strategies would be extremely useful in education.

A unique aspect of this study will be to examine for the first time potential relationships between cognitive style and contextual learning. Theories and practices in these two arenas have evolved independently. This research will represent an early attempt to consider them in relation to one another.

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COLLABORATIVE LEARNING ON THE WORLD WIDE WEB USING A PROBLEM-BASED LEARNING APPROACH

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INTRODUCTION

While the Web is growing in popularity among university educators as a means for enhancing teaching and learning, there appears to be a tendency among many teachers to simply reformat on-campus course materials and learning strategies into an on-line form (Parker, 1997). Such an approach tends to significantly underutilize this technology and limits many of the learning opportunities that are afforded. Many new strategies are now being proposed for designing effective Web-based learning environments (e.g. Collis, 1997a). Common elements in the suggested design strategies are motivational and interactive learning activities based on collaborative activities.

NEW MODELS FOR UNIVERSITY LEARNING

One strategy that holds considerable potential for supporting more open forms of teaching and learning and involving collaborative learning activities is problem-based learning. Problem-based learning involves learning through

goal-directed activity situated in circumstances which are authentic in terms of the intended application of the learned knowledge (Elen & Clarebout, 1998). Problem-based learning is a curriculum approach which helps the learner frame experience as a series of problems to be solved in which the process of learning unfolds through the application of knowledge and skills to the solution of real world problems, often in the contexts of real practice (Bligh, 1995).

There have been many previous projects involving problem-based learning in Web environments (e.g. Collis, 1997b) but the majority of these have tended to involve quite sophisticated and customized Web domains. This project sought to explore the prospect of developing content-free Web spaces for problem-based learning activities using simple models that are readily adaptable by other faculty. This process initially necessitated the development of an elementary structure for the Web problem-based environment and an exploration of issues associated with its implementation and use in classroom settings.

DESCRIPTION OF THE LEARNING ENVIRONMENT

The encouragement to explore and experiment with a problem-based learning setting emerged from problems identified by the principal researcher in his university where faculty were seeking alternative forms of delivery to formal lectures and teacher-directed presentations. A project was therefore devised which involved the development of a problem-based setting to replace the conventional delivery of a course and the use of Web technologies to support information access and collaboration. The decision was reached to initially explore opportunities in an undergraduate degree program involved

with the study of communications technologies, which can be viewed on the Web (Oliver, 1998).

A Web environment was designed to provide students with a summary of the content for each week and the learning outcomes that were intended. As with traditional courses, the content was based on chapters and information from a printed textbook. The format of the weekly learning environment and activities was:

- A content summary of the relevant material for the topic with a series of focus questions to provide students with a structure for an initial exploration of the content through the textbook.

- Web links to provide access to a variety of other resources both on-line and print-based as a means for further exploration of the topic.

- URL posting tool--an on-line facility enabling students to post useful and relevant resources they discovered to a public bulletin board for other students to access and use in their inquiry.

- A weekly problem, designed in a fashion which encouraged students to explore and inquire and which provided a degree of scope and latitude in the solution. The problems reflected tasks similar to those which the learners might meet outside the classroom. At the same time, the

problems were developed to reflect the ways in which it was believed students might need to use this information.

- Communications support--students were required to work in groups and encouraged to collaborate using e-mail in developing their solution. Once the group was satisfied with the solution, another tool was provided to enable it to be submitted to a public bulletin board where the other groups' solutions were displayed.

This learning setting was implemented and evaluated across a full semester course and information was gathered to guide future and more general applications.

DISCUSSION

The initial implementation of this new curriculum presented some interesting challenges and opportunities and provided substantial feedback guiding the plans for future and expanded use of the system. Some of these findings included:

- Student motivation--the authors were required to develop strategies to encourage and motivate the learners to accept and enjoy this alternative form of teaching and learning. The onus for learning moved directly to the students and it was important to ensure that the learners were

comfortable and accepting of the changes to their roles.

- Learning strategies--there were large differences observed in the times spent by students in different learning activities. It was also apparent that different groups developed widely varying strategies for the problem-solving process. The strategies varied between shared tasks and responsibilities in the problem solving process to instances where students assumed particular roles. Learning was quite variable among students and groups.

- Group composition--the ways in which the groups were selected and composed had a substantial influence on the quality of the solutions generated and on the learning achieved by the various group members.

- Problem selection--the different problems across each work provided vastly different settings for student inquiry and exploration. It was evident that problem selection was a critical factor in determining the scope and extent of learning as well as the enjoyment felt by students in collaborating to develop their solutions.

- Level of enjoyment--the students indicated through their activities and responses to questioning that the components of the course that provided the highest degrees of enjoyment and motivation were those which were teacher-centered and classroom-based. The factors which contributed least to enjoyment were the group work, the URL posting and the course content, all factors associated with on-line learning. This suggested the need for developers of on-line environments to remain alert to the motivational needs of their learners and to ensure teacher presence wherever possible.

- Supports for learning--the problem-based setting involved a number of procedures and routines not found in traditional classrooms. Examples include Web searching, asynchronous communication, resource sharing and collaborative efforts. Students generally saw all these activities as providing reasonable to strong levels of support for their learning.

- Personal skills development--the use of a problem-solving strategy as the basis for teaching and learning in a course appeared to provide considerable scope for developing students' personal skills such as information literacy, metacognition

and self-regulation. Students suggested that they saw the course as contributing reasonably, and in many cases, significantly, to their development in these areas.

CONCLUSIONS AND RECOMMENDATIONS

The findings from this initial exploration with a Web supported problem-based learning environment have been positive and have provided encouragement to the authors to continue their explorations. The model appears to have strength in providing guidance for the development of an implementation strategy that can be used to enable faculty to embrace various learning settings.

The next stage in the project has been to develop a Web tool that can be customized to enable faculty to create on-line problem-based learning activities for their classes. This tool will enable faculty with little technical expertise to develop the necessary Web pages and settings to implement problem-based learning activities. The authors are developing guidelines to assist staff to create appropriate applications of these tools by suggesting places where problem-based learning could be useful and by suggesting how to choose problems and how to implement them effectively. The next study will be an exploration of factors associated with faculty reception of these ideas and tools and the development of additional tools which can be customized to support effective learning on-line.

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TRANSFORMATIONAL GROWTH

AND EDUCATIONAL CHANGE

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INTRODUCTION

The hot topic of discussion in post-secondary education today is the nature of change. There is little disagreement over the general direction of change. It is away from the traditional classroom and toward something that can be better described as a learning environment, rather than a teaching environment.

There are some realities that are generally accepted. The backgrounds of post-secondary students are more diverse than they were even a decade ago--with both positive and negative aspects--making traditional curriculum appropriate for a smaller proportion of post-secondary students. Also, the focus of most post-secondary institutions is away from curriculum that suited the classroom setting and faculty preferences. Rather, the focus is toward activities outside the traditional classroom which are more directly related to the learning needs of students. Finally, the development of new technologies--in computers and telecommunications--is making new learning relationships possible.

The context of the discussion about these issues within the educational community is interesting and innovative, but it is hindered by its isolation from insights into change that other disciplines can offer. Although it may seem an unlikely place to find insight into the nature

of educational change, the subject of economics-- economic growth, more specifically--has something to offer.

Economics often comes up in the current discussion around educational change, but these issues are more properly issues of finance, not economics. This paper is not about the nature of educational finance, but on the underlying forces that are leading to change.

Edward J. Nell--an economics professor in the Graduate Faculty of the New School for Social Research in New York City--has developed an interesting approach to economic growth (Nell, 1998; 1997; 1996; Nell & Phillips, 1995). He takes a much broader perspective on growth than traditional economists. He calls his approach Transformational Growth.

The theoretical basis of his work is to consider the historical process of economic growth as the result of forces for innovation. Innovation, as Nell sees it, is both technological and social in nature. Technology determines what can be produced (in terms of both goods and services) and the social structures must complement the technologies for productive transformation to occur.

The simplest way of conceptualizing this approach to growth is to consider two very different eras--the craft era (or the era of the family firm and family farm) and the age of industrial mass production. In Canada, the craft era could be considered the period before World War I; the mass production age, the period from World War II until about a decade ago, when the transformation began that is currently under way.

Nell has been able to show the results of the transformation from the craft era to mass production by using what he calls the stylized facts of the two periods (Nell, 1997). There is clear evidence of fundamental changes in how economies behaved in the two eras. Although his research focuses on the forces for change in the production of goods and services, extending his

approach into education is easily done. Not only does Nell give some insight into how and why education has changed earlier in this century, he also provides the ability to form a better view of the current transformation.

EARLY EDUCATIONAL MODELS

There are three educational models that are worth reviewing before considering current circumstances. These include the Oxford setting, the rural schoolhouse and the 20th century high school, college or university.

The Oxford Setting. The earliest setting is the traditional Oxford education. At Oxford, the primary learning experience for more than 500 years has been between the student (there to read) and a tutor (a professor). The student reads and prepares papers in the topics the tutor considers appropriate. In the end, the student must write exams set and evaluated by a group of experts in the field (this may or may not include the tutor).

The greatest advantage Oxford students had centuries ago was access to well stocked libraries. Access to information was, and remains, the keystone of education. This environment, in terms of Nell's analysis, could be seen as a craft setting. The tutor customized the topics given the student's background, interests and the areas in which they needed to become proficient. In effect, this setting is one in which learning is self-directed with the tutor acting as a learning facilitator and with an external body conducting the evaluation.

The Rural Schoolhouse. Another setting to consider is the rural schoolhouse of the late-nineteenth and early twentieth century. In this setting several students of various ages and levels occupied the same room and commanded the time of the same teacher. The teacher had the responsibility to organize activities that would move each student along while maintaining some sense of

cohesion among the group. No mean feat. Here, teachers acted in a craft-like way since they had to customize the topics being covered by the students and did so by bringing groups at the same level together. Like Oxford tutorials, this setting provided a way of customizing, but it also achieved some economies in delivering the material. The teacher often did all of the evaluation, but year-end, qualifying exams were sometimes set by an external body--usually a branch of government.

Twentieth Century Setting. The educational setting that dominated the twentieth century is often like any typical high school, college or university. In this setting, a large group of students at a similar level (and most often of a similar age) occupied a classroom where a teacher specializing in a specific subject would deliver lessons and work one-on-one with students who require assistance.

There was little or no customization at the classroom level, only assistance by the teacher to try to keep everyone at the same stage in the course. Customization only came in the selection of programs or courses. Learning was rarely self-directed. In fact, little if any consideration was given to students' abilities (other than prerequisites) or experience. Everyone had to go through the same process at about the same pace while at about the same age.

Unlike the Oxford setting or the schoolhouse, in this setting the teacher rarely acted as a learning facilitator, but rather a deliverer of information. The teachers did the evaluation themselves. Rarely was an external party involved. Although there is an element of craft that remained with teachers teaching those subjects in which they had expertise, this educational setting can best be described as mass production. The same thing was done en masse for all students in a sequential process--moving the students through the assembly line.

DISCUSSION

The clear break comes between the time of the craft setting of the schoolhouse and the mass production setting of the urban classroom or lecture hall. It seems that this was a natural progression given the acceptance of the process by those experiencing it. But, there is much more that lies behind such a change in educational settings than meets the eye. Nell's Transformational Growth suggests that the change be examined as a result of the pressures for innovation--doing things in new ways. Nell also ties such innovation to technological progress.

Looking back at the Oxford setting, it is clear that the technological driving force, especially in its early stages, was the printing process and the organized collections of books held in its libraries. Bringing people together around well stocked libraries made perfect sense. A self-directed, facilitated, education also made perfect sense given the limited access to information and the wide-ranging abilities, interests and backgrounds of students. Their students came from craft-based systems so each one had unique educational backgrounds.

Producing goods in a mass production economy changed the way many people lived and had important ramifications for education. With the development of the technologies necessary to make mass production of goods profitable came urbanization. To build products in a mass production environment a producer needed a nearby stock of raw material and labor, and easy access to markets.

The skills of the workers that were needed in mass production also changed. Basic reading, writing and arithmetic skills became more necessary as mass production became more and more sophisticated. In terms of production, it was clear that producing goods en masse was also economical. High fixed costs, high volume of output and the division of labor into smaller and smaller

activities made goods cheaper to produce than craft-based production. Labor was more productive and, therefore, better paid. These lessons in mass production were passed on to the educational system.

Large schools were built where many students would be put through the same educational process. The large size of the facilities enabled economies of scale to be achieved. Labor (the teachers and administrators) fulfilled very specific tasks within the process. The resulting products (the students) went through almost identical experiences--especially if they were in the same program.

This type of educational setting dominated the mass production age since it provided the type of education that a mass production economy needed and fitted perfectly into the culture of mass production. As Nell's theory of Transformational Growth would suggest, the mass production age came about due to the development of the kinds of technology that could be used in a mass production environment. The educational setting of this era reflected these technological innovations. In general, the educational setting of the mass production age was a manifestation of the technological development of the time.

There are forces currently acting on the economy that can provide some insight into the forces that may also be moving education. In manufacturing, the emerging method of production has characteristics of both the craft-age and the age of mass production. In the craft-era, it was very common to produce a different item every time. In mass production, many identical units were produced. Each of these modes of production required specific types of technologies.

Craft-technologies did not lend themselves to mass production, nor did mass production technologies allow for unique products to be produced. The technology that is now emerging is making mass customization possible. Automobile manufacturers are now able to produce one

unique car after another--according to customers' specific needs. Technological innovations have made it possible for an important aspect of craft production to be done in a mass production environment.

Technological advancement will also enable educators to combine favorable aspects of the craft-like educational setting of Oxford's tutorial system with favorable aspects of the mass production setting. Customization will come in the form of time and place flexibility, self-directed curriculum, the ability to have access to broadly based facilitators, and, most importantly, access to information that is not even available in the world's best libraries.

A crucial technological advance that makes most of this possible is having access to information necessary for a good education without having to be in the same place as the educators. Innovations in telecommunications technology, computer technology and computer software have made it possible for students to access information in a location other than a classroom or a library--often in their own home.

It is technological advancement that will make it possible for the educational setting of the future to be a mix of the Oxford setting and the ability to provide a similar experience to a very large group of students as in mass production. But technological change was not sufficient to transformation an economy from the craft age to the age of mass production. It was necessary for new social structures to complement technological change. So, too, in education.

There is something to be learned from the history of economies that provides some useful insight. There are many examples of countries that were relatively more advanced in the craft age than they were during the mass production age. For example, consider the relative success of Canada and Argentina in the late nineteenth century and the late twentieth century. It can be argued that both had

access to modern technologies, but Canada put in place social structures that complemented mass production technologies that made it more successful in this century.

CONCLUSIONS

The lesson to be learned from Nell's Transformational Growth is that co.nplementary structural innovation must accompany technological change if a transformation is to be successful. Those involved in the current educational setting often see and hear about technological change that has the potential to move faculty into another setting. Far less often is anything heard about changing educational structures to complement the technological change.

If a move to a setting that combines the best of both the craft and mass production settings is to occur, individuals must look for structures that can now support a new setting. In doing so, there must be a willingness to identify those structures that must be abandoned and those that must be established if the transformation is to be successful. Stubbornly holding on to the tra\tions of the mass production setting may serve the interests of educational Luddites, but it will not serve the future educational needs of learners.

As far as the craft setting is concerned, it seems very possible that the role of the learning facilitator (the new age tutor) will take into account the learners' proficiencies, experiences and interests to prepare them for evaluations that will be done by a third party. To provide such a role for students, learning facilitators will have to have a broad range of knowledge to draw upon. No longer will the narrow specialization of the mass production setting be sufficient to provide what the learner will require. The facilitator will need to keep up with the latest sources of information knowing that the examiners will be

ensuring that the students they certify will be at the cutting edge of the subject. Learning facilitators will have to be given the time to keep current and maintain their breadth of proficiencies. This setting will also require that the facilitator give up their ultimate evaluative role.

Mass customization in education will mean that the facilities, support services and learning facilitators will have to provide more varied educational experiences to just as many, or more, students than were served in the mass production setting. Educational administrators will have to plan more carefully so that the necessary fixed capital can be put in place as educational technologies change. Organizational, academic and intellectual flexibility in the learning facilitators will be absolutely necessary if they are to be efficient in their new roles. This will require radical changes in contractual relationships with learning institutions. The contracts built to serve the mass production setting will be inappropriate in the new learning setting.

There is little doubt that education is in the early stages of a transformation--a transformation driven by technological change. If Nell's insights into economic transformations are to be used, it can be foreseen where the forces for change may be leading. The transformational growth of economies provides a perspective on the social nature of technological change, the importance of our place in history, and the possibility of changing social institutions to support progressive growth. The learning facilitators of the future will have to be broadly based learners themselves. Perhaps a beginning is to learn from Nell's economics.

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UNDERGRADUATE LEARNING MODES AND NEW TECHNOLOGIES: LESSONS FOR THE FACULTY

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INTRODUCTION

Increasing numbers of institutions, including major research universities, have implemented or plan to launch new initiatives to improve undergraduate education. They continue to wire their campuses, fund special discipline-specific computer labs and perhaps even require or provide their first year students with laptops. The latter assumes that more technological/electronic sophistication translates automatically into more students using computers as a mode of learning in their majors. Yet, most faculty and administrators remain unaware of the actual modes undergraduates employ to learn about their chosen curricula. Moreover, most campuses have not quantified the extent and frequency with which students turn to the Internet/Web and computer technology as modes of learning on campus. The basic ethnography has not been conducted.

When Robert Barr and John Tagg published their paper on the paradigm shift from teaching to learning (1995), they drew distinctions between active modes (seen most often in the "Learning Paradigm") and passive modes (characteristic of the "Instruction Paradigm"). Angelo (1997) proposed seven "shifts" and seven "levers" to

transform campuses into learning communities, building on Barr and Tagg. Studies of how undergraduates learn and what they learn always focus on the curriculum and seldom, if ever, address the area of self-directed learning in the "outside" world. This pilot study assesses computer technology, the Internet/Web and other modes students adopt to explore and learn about their majors and avocational interests as well.

DESCRIPTION OF THE STUDY

William Paterson University is a comprehensive state-supported institution enrolling over 9,000 students and offering 29 undergraduate majors and 17 master's degree programs in 5 Colleges--Arts and Communication, Business, Education, Humanities and Social Sciences, and Science and Health. The University claims to be at the forefront of New Jersey's higher education institutions (public and private) in its computer connectedness and facilities, which include several special student computer labs (history, computer science, cognitive science, writing, business, languages), several public computer labs distributed across the campus, an electronic resource center in the library, a computer instruction lab and 6 wired auditoriums. Additionally, the library and most departments received grants to purchase instructional software and hardware over the past several years.

A study was designed and piloted in November, 1998 to explore, in part, the extent to which undergraduates actually employed computers and especially the Internet/Web in learning within their majors. The main focus of the study, though, was to discover the types of learning modes students used in both directed learning (in major courses) and in self-directed learning (hobbies or avocational interests), and what role computer technology played in each.

A total of 116 respondents completed two-page questionnaires; interviews were conducted with a third of this group. Participating students were enrolled in one of three general education courses in the social sciences (one at the 100 level, one at the 200 level, and one at the 400 level). The majority (95) were juniors and seniors, and therefore the students who were most likely to have experienced the greatest impact of computer technology on the campus over time. Sixteen were sophomores and only 5 were freshmen. Students in the sample came from 27 majors with 7 still undeclared. The questionnaire was designed to elicit modes of learning about hobbies on one page and modes of learning about major courses on another. Additional questions addressed basic demographics, frequency of e-mail usage, GPA and reasons for selecting the major(s).

FINDINGS

Overall, students in this sample employed many more varieties of learning modes to address avocational interests than they employed in course work for their academic majors. Females who reported using the Internet/Web were twice as likely to employ it to learn about hobbies than to learn about their curricula, while males who turned to the Internet/Web were four times more likely to use it for hobbies than for their majors. Both genders, though, tended overwhelmingly to limit their computer use to word processing and e-mail, two activities that neither gender identified as learning modes.

Modes Of Learning: Hobbies

In identifying self-directed modes of learning, students most often reported active modes when exploring their avocational interests. Also, students listed several

different modes, both active and passive, when completing this inventory. However, the Internet/Web or any computer technology was cited by only 13 of the 40 males (32.5%) and 17 of the 76 females (22.4%).

The modes cited by students were as follows--from most frequently to least frequently cited: 1) friends; 2) relatives; 3) various media sources (television, magazines, catalogs, newspapers, videos, movies, recordings); 4) stores/vendors; 5) actual practice (as in sports, music, dancing, writing); 6) site visits; 7) events; 8) organizations; 9) Internet/Web/software; 10) exhibits and contests; 11) travel; 12) sending for information; 13) taking special classes or seminars; and 14) apprenticeships. Students drew on multiple modes in sequence and also simultaneously. Most of the reported Internet/Web usage derived from campus-based access. Students also reported being involved in informal, self-selected groups to participate in and learn more about their avocations--i.e., mini learning communities.

Modes Of Learning: Major Curricula

The modes of learning inventoried by the students in their major curricula appear to be directed or modeled by instructional techniques experienced in secondary schools and then replicated at the University. While the three primary modes reported are all passive, there was some usage of the Internet/Web and computer technology reported by three of the 40 males (7.5%) and nine of the 76 females (11.84%).

The modes cited by students were as follows--from most frequently to least frequently cited: 1) reading; 2) studying; 3) attending class and listening; 4) taking notes; 5) doing homework; 6) making flash cards; 7) memorizing; 8) watching videos; 9) Internet/Web/computers; 10) writing and rewriting;

11) experience (internships and teaching practicum); 12) going to the library; 13) speaking to professors; and 14) speaking to fellow majors. Not one of the 116 students mentioned discipline-based clubs (which abound on the campus) and only one student mentioned speaking to friends within the same major as a mode of learning. Therefore, students appear isolated in the various modes of learning about their major curricula and offer very redundant lists.

E-Mail Usage

In contrast to the low frequency reported by the sample for Internet/Web/computer use as a learning mode for either hobbies or major curricula, e-mail usage was substantial. Fully 75% of the males and 90.8% of the females in the sample reported logging on for e-mail at least once per week. Of the 55 students reporting e-mail usage 3 or more times per week, about half were males and half females.

Lower e-mail usage among many of the students appears to be a factor of their access being limited to campus computers. Since William Paterson is primarily a commuter institution and since students covet three-day class schedules, the frequency of e-mail access reflects their on-campus presence. Very few faculty offer listservs as an additional mode of learning, even though this avenue is available to all and each faculty office is equipped with a networked computer.

CONCLUSIONS AND RECOMMENDATIONS

A well-wired campus with clusters of discipline-dedicated computers labs, several public computer labs and fully-mediated auditoriums may mean that students who have spent three or four or even five years in the midst of

this new technology may only be making the most rudimentary use of it. Furthermore, this student sample suggests that faculty, even when provided with the necessary hardware and software in their offices and on their networks, seldom include any computer technology or Internet/Web-based instruction in their courses.

Perhaps more importantly, student responses indicate an overwhelming reliance on an instructional paradigm in our classrooms, with studying, reading, and attending classes listed as the preferred (or at least the most frequently reported) modes of learning. These modes, it would appear, are shaped and directed by the faculty and then rewarded by the faculty in the various assessments employed to gauge student learning. In contrast, when left to direct their own learning experiences, students choose from a much broader spectrum of learning modes. No student wrote the word "studying" in the inventory of ways employed to learn about avocations. Yet, most claimed to be "expert" or at least "very good" at their hobbies.

It appears that students exit high school with a dichotomy of learning experiences--one that is essentially active and self-directed and another that is quite passive and directed. With little evidence of changes in post-secondary education, it may be time to construct new initiatives tailored more toward the learning paradigm students may already be familiar with in their avocational interests, but have seldom, if ever, transferred to their academic curricula.

The role that computer technology (and the Internet/Web) will play among the new initiatives to improve undergraduate teaching needs to be on the agenda very early. It should be a fundamental component of every first year or freshman experience course and as an integral part of each basic general education course as well. By building on that foundation, the various major curricula

may have an easier time integrating computer technology across the board.

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TECHNOLOGY IN PROBLEM BASED LEARNING COURSES--HOW CAN IT HELP?

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INTRODUCTION

Problem Based Learning (PBL) is a student centered pedagogy that can motivate students to understand science and help them gain an integrated, interdisciplinary perspective (Barrows, 1988). This approach also promotes training in problem solving skills, collaborative working and self study skills. It is now coming to be recognized as a powerful pedagogy to engage undergraduate students in active learning. There is widespread interest in using PBL in the undergraduate curriculum (Ram, in press; Dods, 1996; Hughes, 1993). Many educators are tempted but are either wary of the time demands or by their lack of experience in the area. This paper provides a description of how technology can help the instructor of PBL courses save time, deliver the course more effectively and evaluate the course better.

WHAT IS PROBLEM BASED LEARNING?

A PBL classroom is organized around collaborative problem-solving activities which provide a context for learning and discovery. Learning from problems places knowledge in the context of use. It has been proposed and implemented in several forms to help students learn complex domains (Barrows, 1985; Brown, Collins, & Duguid, 1989; Schank, Fano, Bell & Jona, 1993;

Williams, 1993). Results from medical schools have demonstrated that PBL students are better at applying their knowledge than traditional medical students (Hmelo, Gotterer, & Bransford, 1994). Recent evidence suggests that similar effects may be found at the undergraduate level as well (Hmelo and Cote, 1996; Shikano & Hmelo, 1996) and has consequently encouraged use of PBL in the undergraduate curriculum (Bras, Hmelo, Mulholland, Realff, & Vanegas, 1995; Ram, in press).

In a PBL classroom, students work in collaborative groups--learning is student-centered. The teacher is a facilitator rather than an instructor in the traditional sense. Students approach the problem with a specific role and learn to use the PBL methodology to understand the problem, to generate hypotheses and develop a strategy to address the issues in the problem, to solve the problem and to evaluate their results.

The tutor guides the inquiry process so that students elicit data about the problem, look for additional information in the inquiry materials provided, identify inadequacies in their knowledge--the learning issues--and undertake to correct these deficiencies. All of these activities are undertaken in order to solve the problem. The tutor models the problem solving process initially by asking questions that the expert problem solver would ask, "What does this piece of information suggest?" or "What do you think we need to do here? " rather than lecturing or providing an answer. The success of the process is evident when students learn the cognitive processing and take over the problem solving process without interventions from the facilitator.

WHY IS PBL DIFFICULT TO IMPLEMENT IN THE UNDERGRADUATE CURRICULUM?

In this pedagogy, the choice of problem largely determines the probability of success. The premise of PBL is this--if we give students a challenging task that engages them, they will learn to solve problems and they will learn the associated knowledge in order to solve the particular problem at hand. Their learning will be deeper and more meaningful and will last longer since it is knowledge that they have constructed themselves within a context and in response to a need. However, this presupposes designing a task or a problem that will engage the entire class and also satisfy the curricular needs.

PBL problems must: 1) be based in compelling, real-world situations; 2) generate multiple hypotheses; 3) exercise problem-solving skills and require creative thinking; 4) require knowledge and skills that satisfy curricular objectives; and 5) be integrated and contain components of more than one discipline (Barrows, 1985; Ram, in press). Once a suitably compelling problem has been chosen, it is important to bring the problem home to the students and to engage and excite them through the use of simulations, videos, newspaper or popular magazine articles, dramatization, etc. It is also important that the problem has a clearly defined role for the students to adopt. The problem statement should also specify the deliverables expected of the students at the end of the course.

Another demanding task is to ensure that the problem satisfies the curricular goals of the course. This is a very important concern since everyone has to work within a curricular framework. Students move on from one course to others which have expectations of the skills and knowledge that students should have acquired in the prior course.

Another important concern is the difficulty of running PBL style classes for larger enrollment courses--often the case in introductory courses where such pedagogy is needed most. Finally, one of the most difficult aspects of PBL is the development of suitable evaluation protocols--both summative and formative. Instructors need to evaluate student learning as the course proceeds and give students grades. They also need to evaluate the success or failure of the pedagogy and compare the results with the goals of the course. *Did the problem cover the syllabus? Did the students learn to solve problems, collaborate, evaluate themselves etc?* These important questions are difficult to answer in a quantitative way.

HOW CAN TECHNOLOGY HELP THIS FACULTY INTENSIVE PEDAGOGY?

This author has used technology at different stages of a course to aid the PBL process. In the early stages where the problem is presented to the students, additional information about the problem is made available through Web sites designed for the specific problem. These sites point to reliable sources of information and can provide guidance that is very valuable in the initial stages. In the next stage, through electronic bulletin boards or interactive Web sites, students in large classes can conduct online discussions to augment their classroom interactions.

Students quickly adapt to this method of communication and use their online discussion groups to share information and post the results of their literary searches. The instructor can require students to share their findings with the class through these postings. The author encourages students to respond to postings, to ask for explanations and to reply to questions critically and scientifically. Students are therefore given an opportunity to put their thoughts in writing and also to interact with

their colleagues in a professional manner. The bulletin board becomes the online notes for the class--a record of the material unearthed by the class during the problem solving process.

The electronic discussion boards also help document progress in student development, learning and problem solving skills. In the author's experience, students used these discussion groups not only to communicate information, but also to talk to one another in a more informal manner. Some illustrations follow.

Development of Responsibility. Students took on the responsibility of the problem and the accountability that was involved. They would post messages to organize meetings on weekends and during the Thanksgiving break so they could spend time working on the problem.

Development of Scientific Approach and Organizational Skills. Students posted questions demonstrating curiosity about the scientific principles of the problem. They e-mailed other faculty in related fields (physics and geology) to get further information. They searched Internet sites to obtain useful and up-to-date information.

Development of a Group Feeling. Students learned to work in groups, to feel a responsibility to the group and to work out interpersonal dynamics. In postings, students would apologize for failing to show up for meetings with their group mates or for inadequate literature searches. Students offered to help others out in the lab and, conversely, some asked for help. Students showed a willingness to collaborate and share knowledge with the group and learned to deal with group problems in a constructive way.

Transfer of Knowledge. There were documented instances where students made connections to previous courses and made connections outside the project to real world issues. They would make comments like, " I know

this because I just studied it in my Physics course..." or " I didn't know this, but if you were a child and you drank water with so much nitrates in it, you would be pretty sick..."

Finally, with new interactive Web technology, it has become possible to offer problems online. Students are given information about a problem in stages. They are expected to learn more about the problem and are given a few topics to narrow their searches. At the end of the learning period they submit information they have learned to the Web site so others in the class can view their results. Only then are they allowed to access further information about the problem. This approach, using interactive Web technology, allows the instructor to offer PBL units to a much larger class.

CONCLUSIONS

Problem based learning is a powerful technique to teach problem solving skills to undergraduates while keeping them motivated to learn. PBL courses in scientific disciplines can also help students learn to think about underlying scientific principles and help them view science from an integrated perspective through the use of integrated, authentic problems.

Typically, PBL has not been easy to implement in undergraduate curricula for many reasons. Use of technology, multimedia, electronic bulletin boards, Web sites and Web-based discussion groups can help educators interested in developing PBL courses in many ways--in the delivery of the problem, in assisting students in the early stages by providing them with helpful information, in promoting collaborations, in larger enrollment courses and finally by helping instructors evaluate students and the effectiveness of the course.

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